QUANTUM

HIGH FREQUENCY X-RAY GENERATOR

Installation and Service Manual

Quantum
MEDICAL IMAGING

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SERVICE AND INSTALLATION MANUAL

PRE-INSTALLATION **1➢**

INSTALLATION **2➢**

INTERFACING, PROGRAMMING, AND CALIBRATION **3➢**

ACCEPTANCE TESTING **4➢**

TROUBLESHOOTING **5➢**

REGULAR MAINTENANCE **6➢**

THEORY OF OPERATION **7➢**

SPARES **8➢**

SCHEMATICS **9➢**

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CHAPTER 1

PRE-INSTALLATION

CONTENTS:

1.1.0 INTRODUCTION 1-2
1.1.1 Generator Description 1-2
1.1.2 Features 1-2
1.1.3 Radiographic Performance 1-2
1.1.4 Environmental Specifications 1-3
1.1.5 Applicable Standards 1-3
1.1.6 Electromagnetic Compatibility (EMC) 1-4
1.2.0 SAFETY 1-5
1.2.1 Safety and Warning Symbols 1-5
1.2.2 Safety Notices and Warnings 1-5
1.2.3 Safety Warning Labels 1-7
1.3.0 PREPARING FOR INSTALLATION 1-12
1.3.1 Generator Heat Output 1-12
1.3.2 Generator Power Requirements 1-12
1.3.3 Generator Ground Requirements 1-14
1.3.4 Locating and Mounting the Generator 1-14
1.3.5 Pre-Installation Checklist 1-15
1.3.6 Tools and test Equipment Required 1-16
1.4.0 COMPATIBILITY LISTING 1-16
1.5.0 GENERATOR LAYOUT AND MAJOR COMPONENTS 1-17
1.6.0 CUSTOMER SUPPORT 1-19

1.1.0 INTRODUCTION

This chapter summarizes the main features of the 30 kW, 32.5 kW, 37.5 kW, and 50 kW, 100 kHz X-ray generator (performance, regulatory and compatibility). Safety information is provided, along with environmental, room and installation requirements. This chapter concludes with a pre-installation checklist and a diagram showing the major component layout.

The information in this chapter is provided in order for the installer to be able to plan the site layout prior to installation of the generator.

1.1.1 Generator Description

Depending on model, the X-ray generator is intended for use in radiographic only stationary X-ray systems used for medical, chiropractic, or veterinary diagnostic purposes. The X-ray generator consists of a main power cabinet, and a control console. The main power cabinet contains the HT tank and control circuits, the filament drivers, the low speed starter, and interface connections to the room equipment.

The control console allows the operator to select the technique factors, image receptors, etc., and to initiate an X-ray exposure. The console also contains the AEC interface connections.

1.1.2 Features

The following are the main features of and the options available for the generator:

- Integral low speed starter compatible with X-ray tubes with type “R” stator.
- 24 VAC 150 watts power source for collimator lamp.
- 24 VDC 45 watts power source for system locks.
- Optional AEC. Interfaces with 2 A.I.D. ion chambers.

1.1.3 Radiographic Performance

kVp range:	40 to 150 kVp output capability (125 kVp maximum for some models).
kVp steps:	variable in 1 kVp steps.
kVp accuracy:	± 5 %.
Ripple (kV):	5 % p-p over the full operating range.
Risetime (10-90%):	<1.5 ms.
Time range:	0.004 - 6 seconds.
mAs range	1.0 to 420 mAs (large focus), 0.1 to 100 mAs (small focus) for 30, 32.5, and 37.5 kW generators 1.0 to 600 mAs (large focus), 0.1 to 100 mAs (small focus) for 50 kW generators.
mAs accuracy:	± (10 % + 0.2) mAs.
mA range	25 to 300 mA (30 kW generators), 25 to 325 mA (32.5 kW generators), 25 to 375 mA (37.5 kW generators), 25 to 500 mA (50 kW generators).
Coefficient of linearity:	0.05 (station to station) mAs.
Coefficient of reproducibility:	kV, mAs ≤ 0.04.

1.1.4 Environmental Specifications

OPERATING

Ambient temperature range	10 to 40 °C (50 to 104 °F).
Relative humidity	20 to 80%, non condensing.
Atmospheric pressure range	500 to 1060 hPa (375 to 795 mm Hg).

TRANSPORT AND STORAGE

Ambient temperature range	-25 to 70 °C (-13 to 158 °F).
Relative humidity	5 to 95%, non condensing.
Atmospheric pressure range	500 to 1060 hPa (375 to 795 mm Hg).

1.1.5 Applicable Standards

This series of X-ray generators complies with some or all of the following regulatory and design standards as indicated in the table on the next page.

1) UL187.

2) FDA Center for Devices & Radiological Health (CDRH) - 21 CFR subchapter J (USA).

3) Radiation Emitting Devices Act - C34 (Canada).

4) EC Directive 93/42/EEC concerning Medical Devices (European Community).

5) IEC 601.1, IEC 601.2.7:1998, CSA 601.1, UL2601.1.
-Type of protection against electric shock: Class I equipment.
-Degree of protection against electric shock: Not classified.
-Degree of protection against harmful ingress of water: Ordinary equipment.
-Mode of operation: Continuous operation with intermittent loading (standby - exposure).
-Equipment not suitable for use in presence of a FLAMMABLE ANESTHETIC MIXTURE WITH AIR OR WITH OXYGEN OR NITROUS OXIDE.

6) IEC 601.1.2.
Immunity:

IEC1000-4-2	Electrostatic discharge
IEC1000-4-3	Radiated RF field
IEC1000-4-4	Electrical fast transient
IEC1000-4-5	Surge
IEC1000-4-6	Conducted RF immunity
IEC1000-4-8	Magnetic field immunity
IEC1000-4-11	Voltage dips, interrupts and variations

Emission:
EN55011 (CISPR Publications 11 Emission Standards, Group 1 Class A).

1.1.5 Applicable Standards (Cont)

REGULATORY STANDARD	30 kW	32.5 kW	37.5 kW	50 kW
1) UL187.	√	√	√	
2) FDA Center for Devices & Radiological Health (CDRH) - 21 CFR subchapter J (USA).	√	√	√	√
3) Radiation Emitting Devices Act - C34 (Canada).	√	√	√	√
4) EC Directive 93/42/EEC concerning Medical Devices (European Community).				√
5) IEC 601.1, IEC 601.2.7:1998, CSA 601.1, UL2601.1.				√
6) IEC 601.1.2, CISPR 11.				√

1.1.6 Electromagnetic Compatibility (EMC)

In accordance with the intended use, some models of this series of X-ray generator complies with the European Council Directive concerning Medical Devices as per the table on this page. The CE marking affixed to this product signifies this. One of the harmonized standards of this Directive defines the permitted levels of electromagnetic emission from this equipment and its required immunity from the electromagnetic emissions of other devices.

+

It is not possible, however, to exclude with absolute certainty the possibility that other high frequency electronic equipment, which is fully compliant to the EMC regulations, will not adversely affect the operation of this generator. If the other equipment has a comparatively high level of transmission power and is in close proximity to the generator, these EMC concerns (the risk of interference) may be more pronounced. It is therefore recommended that the operation of equipment of this type such as mobile telephones, cordless microphones and other similar mobile radio equipment be restricted from the vicinity of this X-ray generator.

1.2.0 SAFETY

1.2.1 Safety and Warning Symbols

The following advisory symbols are used on the safety warning labels, and/or on circuit boards, and/or on the operator console.

	High voltage symbol used to indicate the presence of high voltage.
	Warning symbol used to indicate a potential hazard to operators, service personnel or to the equipment. It indicates a requirement to refer to the accompanying documentation for details.
	Radiation exposure symbol used on operator console. Lights to indicate that an exposure is in progress. This is accompanied by an audible tone from the console.
WARNING *THIS X-RAY UNIT MAY BE DANGEROUS TO PATIENT AND OPERATOR UNLESS SAFE EXPOSURE FACTORS AND OPERATING INSTRUCTIONS ARE OBSERVED.*	Radiation warning label on operator console. Never allow unqualified personnel to operate the X-ray generator.

1.2.2 Safety Notices and Warnings

WARNING: ***THIS X-RAY UNIT MAY BE DANGEROUS TO PATIENT AND OPERATOR UNLESS SAFE EXPOSURE FACTORS AND OPERATING INSTRUCTIONS ARE OBSERVED.***

WARNING: ***PROPER USE AND SAFE OPERATING PRACTICES WITH RESPECT TO X-RAY GENERATORS ARE THE RESPONSIBILITY OF USERS OF SUCH GENERATORS. CPI CANADA INC. PROVIDES INFORMATION ON ITS PRODUCTS AND ASSOCIATED HAZARDS, BUT ASSUMES NO RESPONSIBILITIES FOR AFTER-SALE OPERATING AND SAFETY PRACTICES.***

THE MANUFACTURER ACCEPTS NO RESPONSIBILITY FOR ANY GENERATOR NOT MAINTAINED OR SERVICED ACCORDING TO THIS SERVICE AND INSTALLATION MANUAL, OR FOR ANY GENERATOR THAT HAS BEEN MODIFIED IN ANY WAY.

THE MANUFACTURER ALSO ASSUMES NO RESPONSIBILITY FOR X-RAY RADIATION OVEREXPOSURE OF PATIENTS OR PERSONNEL RESULTING FROM POOR OPERATING TECHNIQUES OR PROCEDURES.

1.2.2 Safety Notices and Warnings (Cont)

X-ray radiation exposure may be damaging to health, with some effects being cumulative and extending over periods of many months or even years**. Operators and service personnel should avoid any exposure to the primary beam** and take protective measures to safeguard against scatter radiation. Scatter radiation is caused by any object in the path of the primary beam and may be of equal or less intensity than the primary beam that exposes the film.

No practical design can incorporate complete protection for operators or service personnel who do not take adequate safety precautions. **Only authorized and properly trained service and operating personnel should be allowed to work with this X-ray generator equipment**. The appropriate personnel must be made aware of the inherent dangers associated with the servicing of high voltage equipment and the danger of excessive exposure to X-ray radiation during system operation.

Do not connect unapproved equipment to the rear of the console. J1 and J12 on the CPU board are used for interconnect cables to the generator main cabinet. J1 and J2 on the optional AEC board are the AEC inputs from the AEC chamber(s). J5 and J6 are CAEC inputs ONLY. **INCORRECT CONNECTIONS OR USE OF UNAPPROVED EQUIPMENT MAY RESULT IN INJURY OR EQUIPMENT DAMAGE**.

CAUTION: ***DO NOT EXCEED THE TUBE MAXIMUM OPERATING LIMITS. INTENDED LIFE AND RELIABILITY WILL NOT BE OBTAINED UNLESS GENERATORS ARE OPERATED WITHIN PUBLISHED SPECIFICATIONS.***

WARNING: ***HAZARDOUS VOLTAGES EXIST INSIDE THE GENERATOR MAIN CABINET WHENEVER THE MAIN POWER DISCONNECT IS SWITCHED ON. THESE AREAS INCLUDE THE MAIN FUSEHOLDER AND ASSOCIATED CIRCUITS ON THE POWER INPUT BOARD.***

THE CONSOLE ON/OFF SWITCH DOES NOT DISCONNECT THE MAIN POWER FROM THE ABOVE AREAS INSIDE THE GENERATOR.

THE DC BUSS CAPACITORS, LOCATED IN THE MAIN CABINET PRESENT A SAFETY HAZARD FOR AT LEAST 5 MINUTES AFTER THE POWER HAS BEEN REMOVED FROM THE UNIT. CHECK THAT THESE CAPACITORS ARE DISCHARGED BEFORE SERVICING THE GENERATOR.

1.2.3 Safety Warning Labels

This subsection defines the safety labels used inside and outside the generator cabinet.

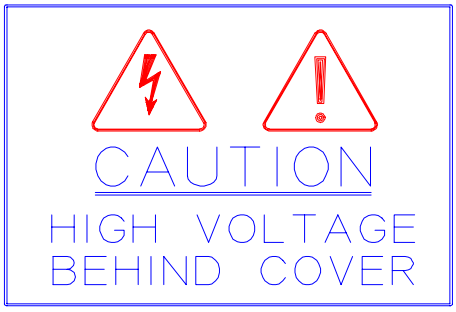
NOTE:	***THESE LABELS AND WARNINGS ARE PROVIDED TO ALERT SERVICE PERSONNEL THAT SERIOUS INJURY WILL RESULT IF THE HAZARD IDENTIFIED IS IGNORED.***

WARNING:	***SWITCH OFF THE MAIN POWER DISCONNECT AND ALLOW SUFFICIENT TIME FOR ALL CAPACITORS TO DISCHARGE BEFORE REMOVING ANY COVERS.***

WARNING:	***IF ANY BARRIERS OR COVERS MUST BE REMOVED FOR SERVICE, TAKE ALL REQUIRED PRECAUTIONS WITH RESPECT TO THE HAZARD(S) AND IMMEDIATELY REPLACE THE BARRIERS / COVERS WHEN THE NEED FOR REMOVAL IS COMPLETED.***

This information is provided to help you establish safe operating conditions for both you and your X-ray generator. Do not operate this X-ray generator except in accordance with these instructions, and any additional information provided by the X-ray generator manufacturer and / or competent safety authorities.

Caution HV Behind Cover Label

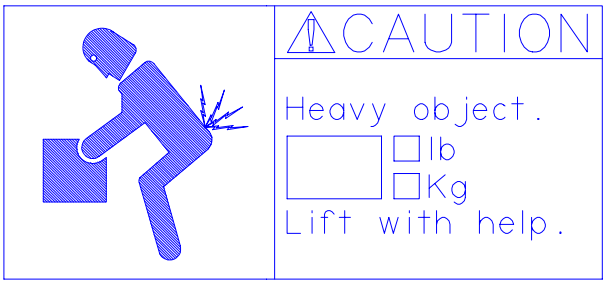


This label is attached to a cover over the inverter board. The inverter assembly is connected to the main DC buss and will have high voltage applied at all times that the generator is switched on. This assembly will remain energized for 5 minutes after either the generator is switched off via the console, or the main disconnect is switched off.

This label is also attached to a cover over the main input fuses on the power input board. This area will have mains voltage applied as long as the main disconnect is switched on.

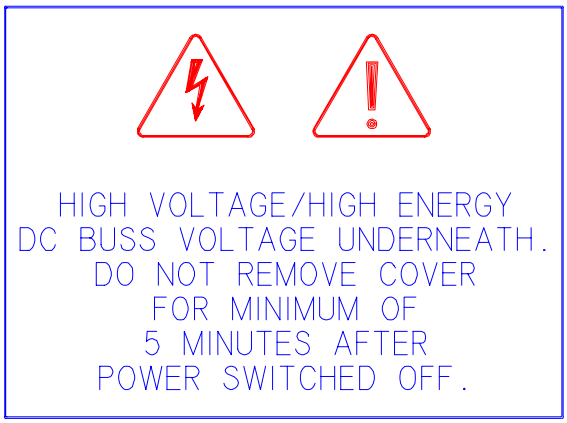
1.2.3 Safety Warning Labels (Cont)

Weight Label



This label is attached to the main cabinet and to the HT oil tank and states the approximate weight of the main cabinet and of the HT oil tank. This label cautions against attempting to lift those assemblies without proper assistance.

DC Buss Label

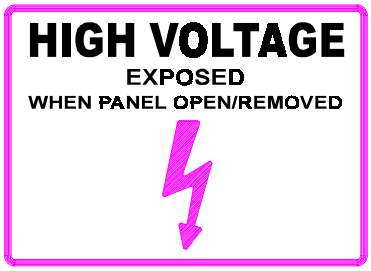


This label is attached to the left, front, and right side panels on the main cabinet The internal capacitors will hold a lethal charge for 5 minutes after either the generator is switched off via the console, or the main disconnect is switched off. Do not remove the cover for a minimum of 5 minutes after the power has been switched off.

WARNING:	***WAIT A MINIMUM OF 5 MINUTES AFTER THE INPUT MAINS POWER HAS BEEN REMOVED BEFORE REMOVING ANY COVERS OR ACCESS PANELS. ONCE THE COVER(S) / PANEL(S) ARE REMOVED CHECK THAT THE VOLTAGE ACROSS THE DC BUSS CAPACITORS IS NEAR ZERO VDC BEFORE SERVICING.***

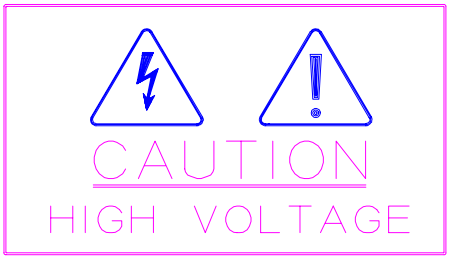
1.2.3 Safety Warning Labels (Cont)

Caution HV Exposed Label



This label is attached to the left, front, and right side panels on the main cabinet. High voltage is present within this cabinet at all times that the mains power is switched on.

Caution HV Label



This label is attached to the power input board, and to the resonant board assembly. The power input board has line voltage components attached that will be live at all times that the main disconnect is switched on. This includes the input fuses, main line contactor, mains rectifier and associated components.

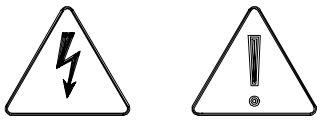
The resonant board assembly has components that may be energized at all times that the generator is on. These components may retain their charge for 5 minutes after the console is switched off, or the main disconnect is switched off.

Danger HV Label

This label is attached to the primary terminals on the HT oil tank. These terminals may be energized at all times that the generator is switched on, and for 5 minutes after the console or the main disconnect is switched off.

1.2.3 Safety Warning Labels (Cont)

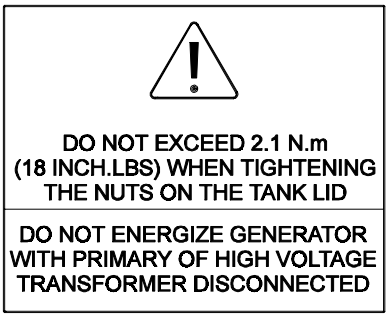
High Voltage Warning Label



This label is attached to the inverter board(s) and to the low speed starter assembly. The inverter assembly is connected to the main DC buss and will have high voltage applied at all times that the generator is switched on. This assembly will remain energized for 5 minutes after the generator is switched off, or the main disconnect is off.

Components on the low speed starter assembly will have 240 VAC applied when the console is switched on.

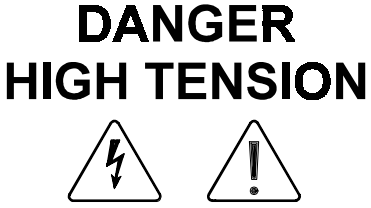
HT Tank - Transformer Terminals Notice


DO NOT EXCEED 2.1 N.m
(18 INCH.LBS) WHEN TIGHTENING
THE NUTS ON THE TANK LID
DO NOT ENERGIZE GENERATOR
WITH PRIMARY OF HIGH VOLTAGE
TRANSFORMER DISCONNECTED

This notice is printed on the HT oil tank lid and indicates that if the power supply inverter leads that attach to the high tension transformer primary terminals are not connected the generator must not be energized.

This notice also cautions against over tightening the nuts on the transformer feedthrough terminals mentioned in the above paragraph.

Danger High Tension Notice



This notice is printed on the HT oil tank lid. High voltage may be present at the primary terminals on the tank lid board, at the output high voltage connectors, and at the mA/mAs measuring jacks if the shorting link is opened for mA/mAs measurements.

1.2.3 Safety Warning Labels (Cont)

Customer Interface Board Notice

110 VAC is present on this board at all times that the generator is switched ON.

AEC Board Notice

Some versions of AEC board will have high voltage present. This only applies to AEC boards fitted with a high voltage supply for ion chambers, and can be recognized by the presence of the high voltage supply components within the dashed outline on the right side of the board. No high voltage hazard exists on this board if these components are not fitted.

Power Input Board Notice

The power input board is fitted with several high power resistors that operate at temperatures sufficient to cause skin burn. Ensure that these resistors have cooled sufficiently after the power has been switched off before servicing.

1.3.0 PREPARING FOR INSTALLATION

1.3.1 Generator Heat Output

The maximum heat output of the main cabinet is 500 watts, with 20 watts maximum heat output for the console. Both the main cabinet and the console are convection cooled. Cooling slots underneath and on the sides of the main cabinet must not be obstructed, and sufficient clearance must be provided to allow adequate air flow for proper cooling. The console should never be covered while it is switched on.

1.3.2 Generator Power Requirements

The table below depicts the power requirements of the 30, 32.5 kW, and 37.5 kW X-ray generators.

Line Voltage	230 VAC ± 10%, 1∅ for 30 kW generators 230 VAC +10% -0%, 1∅ for 32.5 and 37.5 kW generators
Line Frequency	50/60 Hz
Momentary Current	195 Amps
Standby Current	≤5 Amps
Momentary Power Consumption	45 kVa (for 30 and 37.5 kW exposure)

The table below depicts the power requirements of the 50 kW X-ray generators.

Line Voltage	400 VAC ± 10%, 3∅ for 50 kW generators
Line Frequency	50/60 Hz
Momentary Current	120 Amps/phase
Standby Current	≤5 Amps
Momentary Power Consumption	85 kVa (for 50 kW exposure)

1.3.2 Generator Power Requirements (Cont)

NOTE: THE FOLLOWING ARE VALUES RECOMMENDED FOR A TYPICAL INSTALLATION.

Final selection of wire and disconnects must meet the requirements of the local electrical codes and is usually determined by hospital / contractor engineering.

The following table defines the room power requirements for the generator.

AC Mains Cable Size: Distribution Transformer To Main Disconnect (AWG and mm^2)					Disconnect to Generator (15 ft/5 m max)	Momentary Line Current	Service Rating	Distribution Transformer Rating	Ground Wire Size	Apparent Mains Resistance
Series	50 ft (15 m)	100 ft (30 m)	150 ft (45 m)	200 ft (60 m)						
30, 32.5, AND 37.5 KW GENERATOR										
230 VAC	#1 (45 mm^2)	#00 (70 mm^2)	#000 (95 mm^2)	#0000 (120 mm^2)	#4 (25 mm^2)	195 A	100 A	60 kVa	#4 (25 mm^2)	0.05 Ω
50 kW GENERATOR										
400 VAC	#2 (35 mm^2)	#0 (50 mm^2)	#000 (95 mm^2)	#0000 (120 mm^2)	#6 (15 mm^2)	120 A	100 A	70 kVa	#4 (25 mm^2)	0.17 Ω

Recommended Service Disconnect: 100 Amps

- All wiring and grounding should be in compliance with the national electrical code or equivalent.
- All wiring must be copper.
- For all installations, a separate copper ground cable #4 AWG (25 mm^2) is required from the building distribution ground to the ground terminal located inside the main disconnect switch fuse block.
- The disconnect switch shall be located within reach of the operator.

1.3.3 Generator Ground Requirements

- A suitable flexible copper cable #6 AWG (15 mm^2) or larger must be supplied (usually part of the line cable) to connect from the disconnect switch to the main ground of the generator, located to the left of the main fuseblock on the power input board.
- A copper ground cable, #10 AWG (6 mm^2) or larger should be connected from the X-ray tube housing to the H.T. tank ground stud (located at the top of the HT tank).
- If a neutral line is provided with the system under no circumstances is it to be used for ground purposes. The ground must carry fault currents only.

1.3.4 Locating and Mounting the Generator

The main generator cabinet is self standing and does not need to be supported. However, the installation should meet the following requirements:

- The floor must be flat and level.
- The generator installation area must be clean and free of dirt or debris.
- If required, the generator may be anchored to the floor via the hold-down brackets. See Figure 1-1.
- Sufficient room must be provided to allow access to the rear and side panels for installation and service. See figure 1-2 for recommended clearances.
- A cable conduit should be provided from the control console to the main cabinet to allow routing of the control cable if required. Allow for a 2 inch conduit.
- The control console is normally freestanding on a desk or shelf. It may be anchored if necessary.

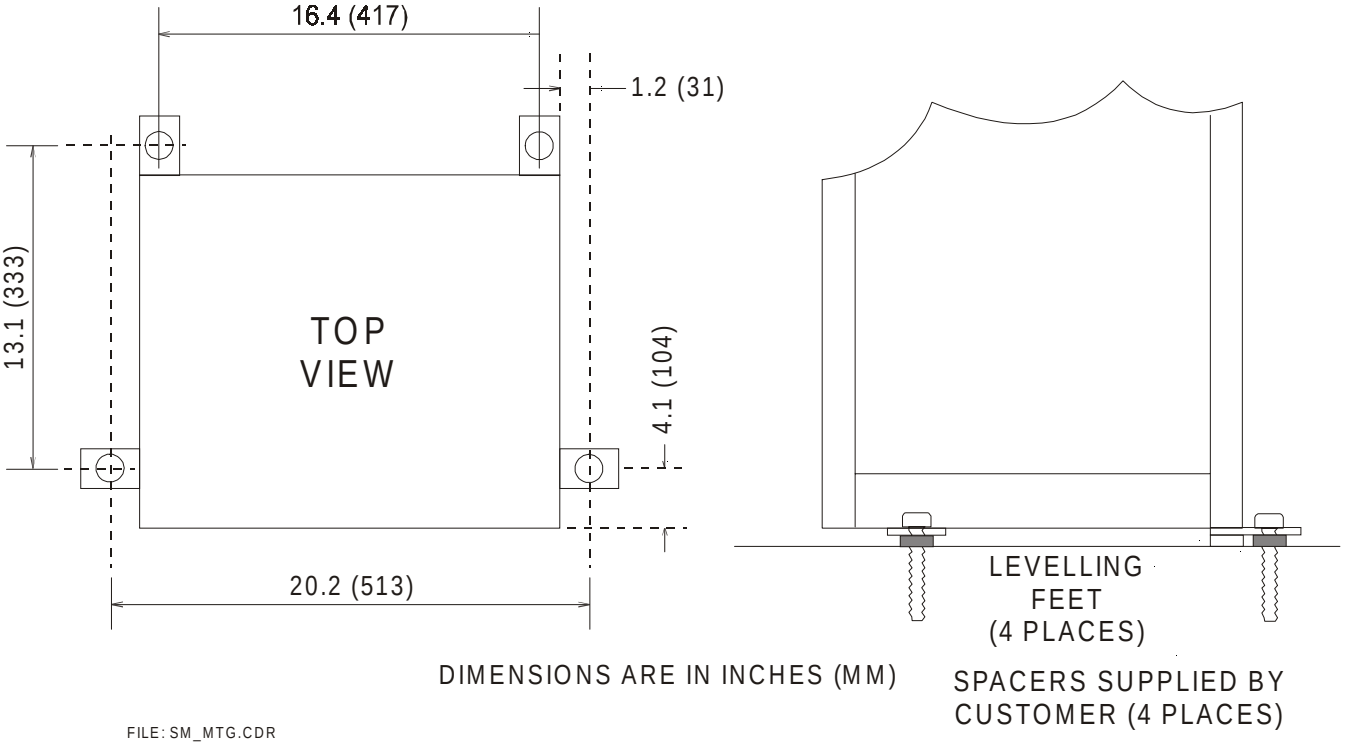


Figure 1-1: Anchoring plates for securing the generator

1.3.4 Locating and Mounting the Generator (Cont)

Figure 1-2 shows recommended clearances around the generator.

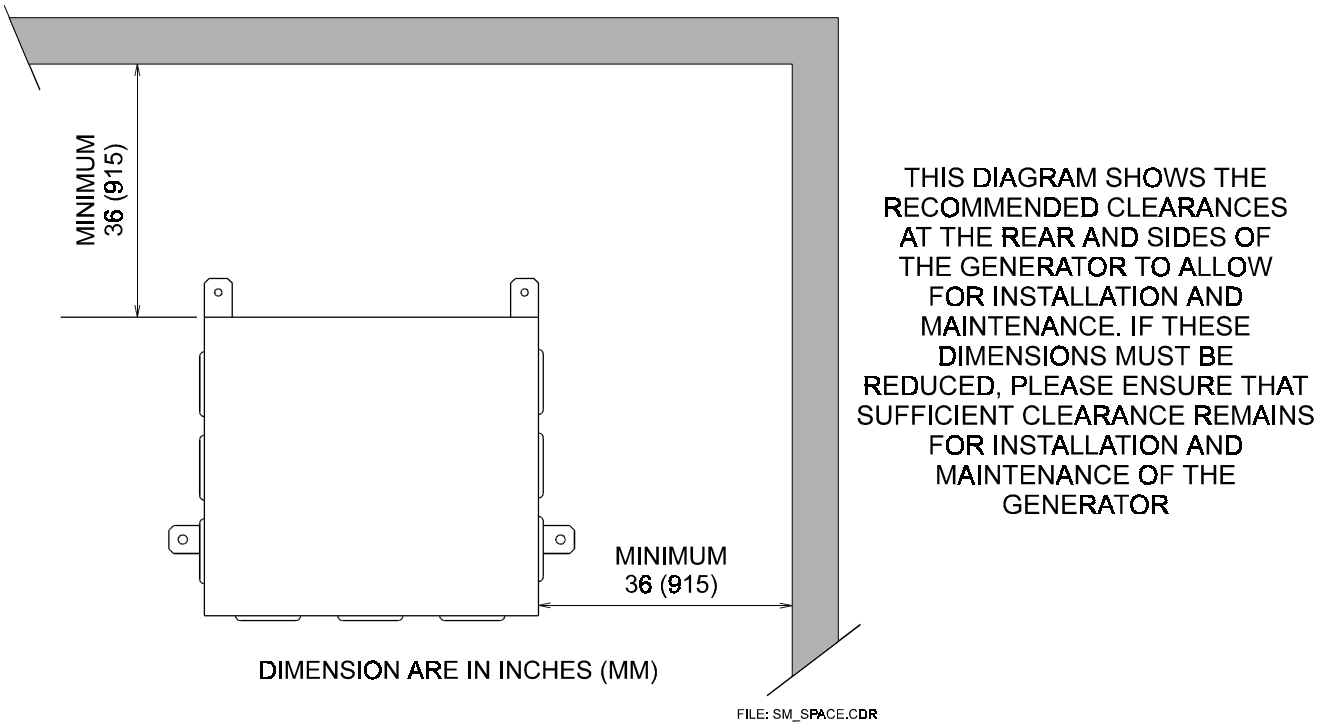

MINIMUM
36 (915)
MINIMUM
36 (915)
DIMENSION ARE IN INCHES (MM)
FILE: SM_SPACE.CDR
THIS DIAGRAM SHOWS THE RECOMMENDED CLEARANCES AT THE REAR AND SIDES OF THE GENERATOR TO ALLOW FOR INSTALLATION AND MAINTENANCE. IF THESE DIMENSIONS MUST BE REDUCED, PLEASE ENSURE THAT SUFFICIENT CLEARANCE REMAINS FOR INSTALLATION AND MAINTENANCE OF THE GENERATOR

Figure 1-2: Generator clearances

1.3.5 Pre-Installation Checklist

Before starting the generator installation, review the following checklist.

CHECK √	DESCRIPTION
	Is there an unloading area to transport the generator from the delivery truck to the inside of the building?
	If the installation is not on the same floor as the delivery entrance, is there an elevator available?
	Is there a transport dolly or similar device to move the generator?
	Do any regulatory bodies need to be notified prior to installation?
	If movers are required, have arrangements for time and equipment been completed?
	Are lifting straps or some other suitable device available to lift the generator off the shipping pallet?

1.3.6 Tools and test Equipment Required

The following is a checklist of recommended tools and test equipment for installation and calibration of the generator.

CHECK √	DESCRIPTION
	General handtools for installation: Wrenches, nut drivers, assortment of screwdrivers, pliers, etc.
	If the generator is to be anchored to the floor, suitable hardware and drills, drill bits etc must be available.
	A supply of connectors for wiring: terminal lugs, caps, splices etc.
	A calibrated DVM which indicates true RMS voltages.
	Dual trace memory oscilloscope with a minimum 20 MHz bandwidth; appropriate leads, probes, etc.
	Device for measuring true kVp. This may be a Dynalyzer equivalent or a non-invasive meter such as the Keithley TRIAD system.
	A calibrated radiation meter with detectors that will allow for R/min and uR type measurements (or uGy and Gy/min).
	A suitable mA / mAs meter.
	A strobe or reed type tachometer to verify that the anode is rotating up to speed.
	A sufficient selection of patient absorbers to allow AEC calibration if this option is fitted. A suggested selection is 3/4 inch Al (quantity 2); 1 mm of Cu (quantity 8), Water in containers of 5.0. 10.0, 15.0 cm thickness.
	Vapor proof compound for the HT terminations.

1.4.0 COMPATIBILITY LISTING

This X-ray generator is compatible with the following equipment:

X-RAY TUBES:

Toshiba E7239 (1.0 / 2.0), Toshiba E7242 (0.6 / 1.5), Varian RAD 12 (0.6 / 1.2), Varian RAD 13 (1.0 / 2.0), Varian RAD 14 (0.6 / 1.2). NOTE THE STATOR WARNING BELOW.

NOTE: THE LOW SPEED STARTER IS COMPATIBLE WITH "R" TYPE STATORS ONLY.

AEC DEVICES:

An AEC option is available to allow interfacing with A.I.D. ion chambers. Refer to Chapter 3 for compatibility.

BUCKY:

Liebel-Flarsheim 110V Bucky or equivalent, Summit J500 Bucky or equivalent.

1.5.0 GENERATOR LAYOUT AND MAJOR COMPONENTS

The dimensions and weight of the generator are shown in the table below.

ITEM	LENGTH	WIDTH	HEIGHT	WEIGHT
Main cabinet in shipping pack	32 (815)	26.5 (675)	46.2 (1175)	210 (95)
Main cabinet unpacked	18 (460)	16 (407)	37.5 (955)	200 (90)
Control console	17 (432)	8.75 (225)	3 (77)	5 (2.25)

The above dimensions are inches (mm), weights are in pounds (Kg).

Figures 1-3 and 1-4 show the major components located inside the main cabinet.

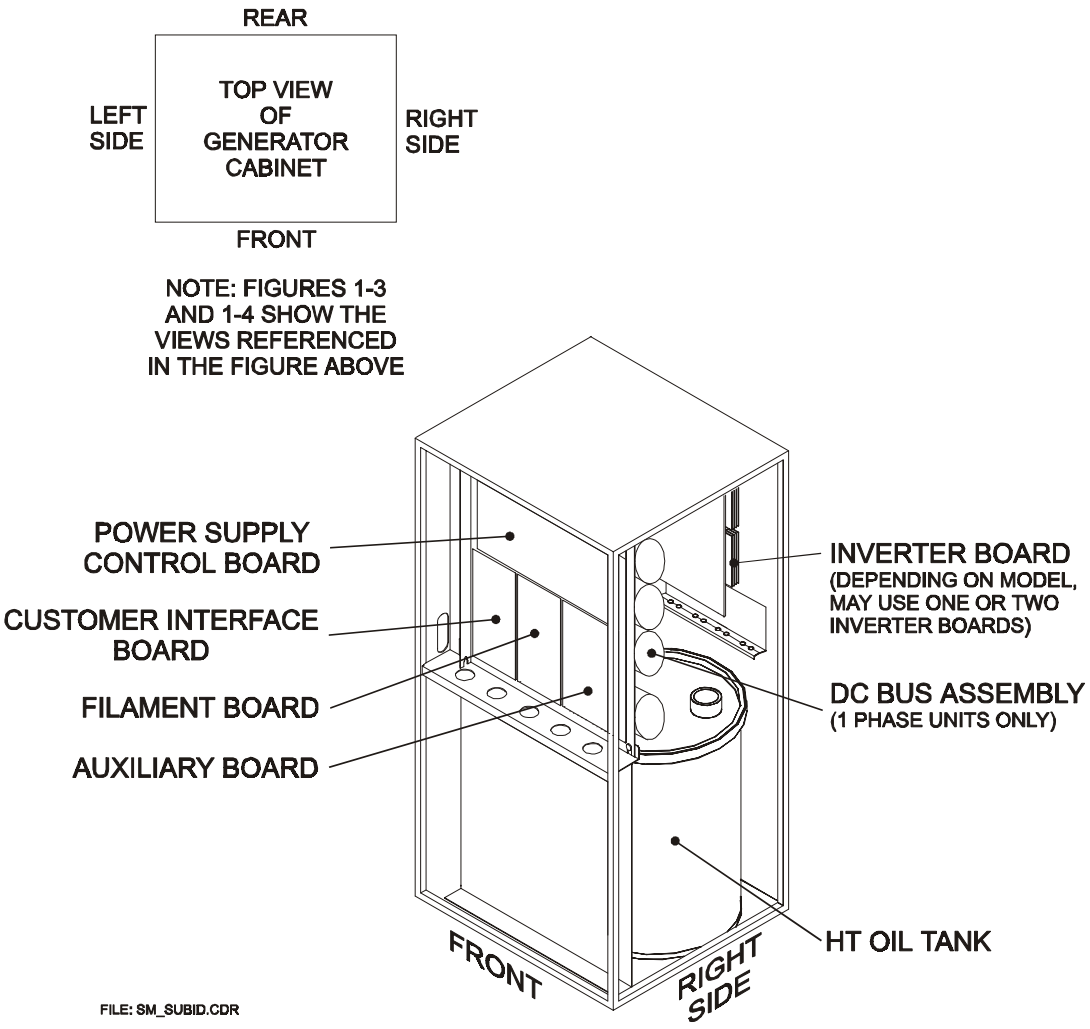


Figure 1-3: Major generator subassemblies view 1

1.5.0 GENERATOR LAYOUT AND MAJOR COMPONENTS (Cont)

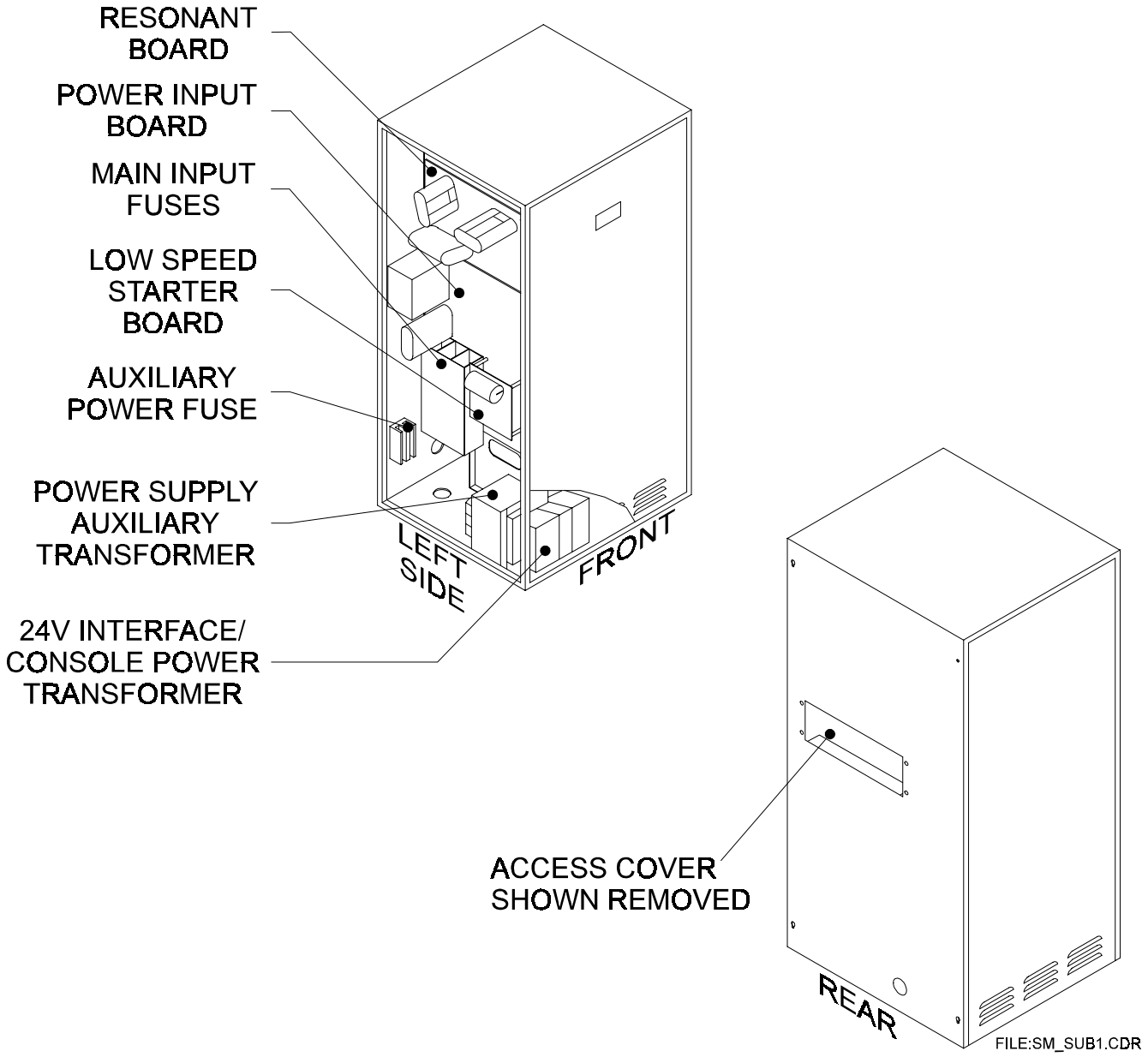


Figure 1-4: Major generator subassemblies view 2

1.6.0 CUSTOMER SUPPORT

Any questions regarding X-ray generator operation should be directed to the Customer Support Department as shown on the inside cover page of this manual.

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CHAPTER 2

INSTALLATION

CONTENTS:

2.1.0 INTRODUCTION 2-2
2.2.0 UNPACKING 2-2
2.3.0 LIFTING THE GENERATOR 2-3
2.4.0 EQUIPMENT PLACEMENT 2-4
2.4.1 Main Cabinet 2-4
2.4.2 Control Console 2-4
2.5.0 WIRING TO THE GENERATOR 2-4
2.5.1 Control Console 2-5
2.5.2 Handswitch (Optional) 2-5
2.5.3 Stator Connections 2-6
2.5.4 Thermal Switch 2-7
2.5.5 Power Line Mains 2-7
2.5.6 High Tension Cables 2-8
2.5.7 X-Ray Tube Housing Ground 2-8
2.5.8 Room Equipment 2-9
2.5.9 Safety Interlocks 2-9
2.6.0 INITIAL RUN-UP 2-9
2.6.1 Initial Voltage Measurements 2-9
2.7.0 TUBE MA AUTO CALIBRATION 2-10
2.8.0 FINAL CHECKS 2-10
2.9.0 UTILITY SOFTWARE 2-10

2.1.0 INTRODUCTION

This Chapter contains instructions for unpacking, positioning, and cabling the X-ray generator, allowing for initial power-up and tube auto calibration.

2.2.0 UNPACKING

WARNING: ***THE GENERATOR MAIN CABINET WEIGHS APPROXIMATELY 210 POUNDS (95 KG) IN ITS SHIPPING CONTAINER.***

THE HT OIL TANK IS LOCATED IN THE MAIN CABINET. ONE PERSON SHOULD NOT ATTEMPT TO LIFT OR MOVE THIS ASSEMBLY WITHOUT PROPER EQUIPMENT OR ASSISTANCE.

1. Inspect the pack for evidence of shipping damage. If there is evidence of shipping damage, note this in the event that a damage claim is justified.

2. Remove the cardboard outer pack. See the cautionary note below before removing the pack.

CAUTION: ***OPEN THE CARDBOARD PACK CAREFULLY. SHARP TOOLS MAY DAMAGE THE CONTENTS.***

3. Set aside the cardboard pack(s).

4. Unscrew the bolts that secure the generator to the shipping pallet. Carefully lift the generator from the pallet. Refer to 2.3.0 for the procedure for lifting the generator.

5. Inspect for internal and external shipping damage.

6. Unscrew the leveling feet at the bottom of the generator by a minimum of 1 1/2″ (35 mm). This will provide the required airflow underneath the generator cabinet and allow room to make leveling adjustments when the generator is placed in its final location.

7. Unpack the control console.

8. Unpack the manuals and any other paperwork that may be packed with the generator.

9. Keep the shipping containers. In case of shipping damage, place the unit(s) back in its shipping pack and notify the carrier and the Customer Support Department as shown on the inside cover page of this manual.

2.3.0 LIFTING THE GENERATOR

One of the following methods is recommended for lifting or moving the generator. Proper equipment or sufficient help is necessary to lift the unit. Refer to figure 2-1 for identification of the panels referenced below.

- Lifting straps may be used with a hoist to raise the generator. The straps should be placed under the generator cabinet and along the four sides to properly support the cabinet.
- Remove the front access panel and the rear wiring access panel from the generator cabinet Temporarily disconnect the ground wire(s) from the cover(s). The metal cross brace found at the front of the cabinet (below the circuit board mounting panel) may be used, in conjunction with the lip at the upper edge of the opening for the rear wiring access panel, as lifting points. Two people (one on each side) will be required to lift the generator cabinet.

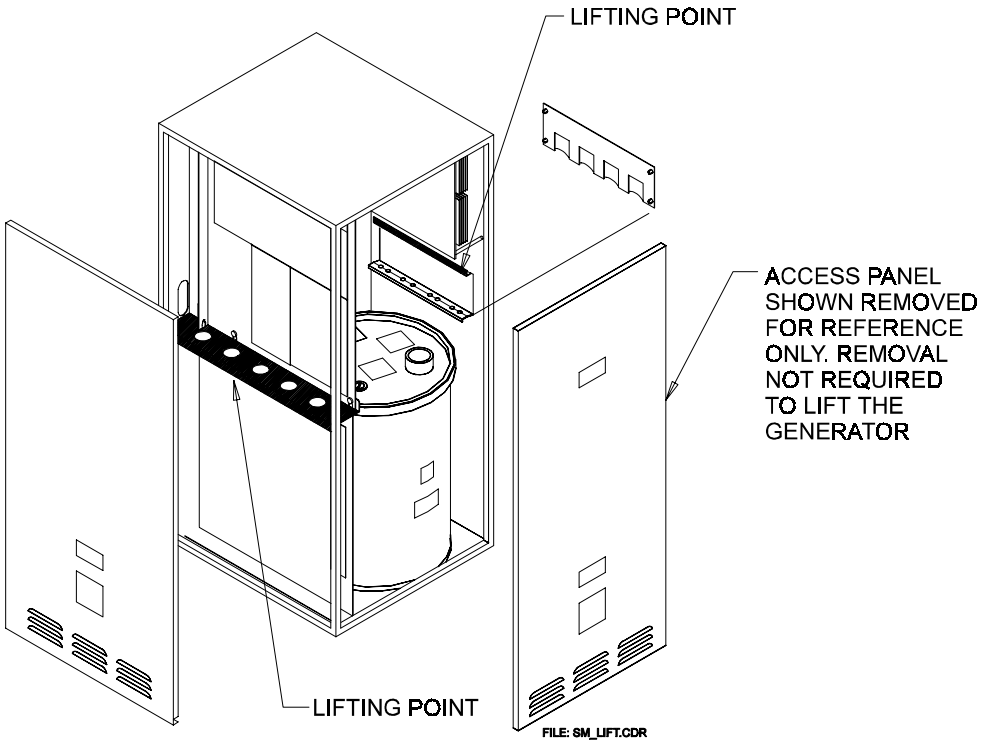


Figure 2-1: Generator lifting points

2.4.0 EQUIPMENT PLACEMENT

2.4.1 Main Cabinet

Place the generator cabinet in a location that will allow the following:

- Easy front and side access for service and sufficient clearance at the rear for room interface cables. Refer to Chapter 1.
- Air circulation - a minimum height of 1 1/2″ (35 mm) is recommended to allow airflow underneath the generator.
- Stable footing - the leveling feet at the bottom of the cabinet will be used to prevent movement during normal operation.
- Close proximity to service disconnect boxes - cables should not be on the floor where they could be stepped on.

After the generator has been placed in it's final location, adjust the leveling feet such that the generator is level and stable. As noted previously, the leveling feet must be unscrewed by a minimum of 1 1/2″ (35 mm) to allow for proper airflow underneath the generator.

2.4.2 Control Console

Position the control console in its intended location and ensure that it is stable. Refer to Chapter 1.

- If the console is located on a shelf, supply index pins or equivalent hardware to the base of the console to prevent slipping.
- Ensure that the console is mounted at a height and angle to allow easy viewing of the displays.
- Leave sufficient slack in the cabling to the console to allow for future service and maintenance.

NOTE:	***DO NOT LOCATE THE CONTROL CONSOLE WHERE X-RADIATION MAY BE PRESENT DURING INSTALLATION OR OPERATION.***

YOU MAY CHOOSE TO TEMPORARILY LOCATE THE CONSOLE NEAR THE GENERATOR FOR INITIAL PROGRAMMING AND CALIBRATION. IF THIS IS SO, PLEASE COMPLETE THE FINAL CONSOLE INSTALLATION PER THIS SECTION WHEN THE GENERATOR INSTALLATION IS COMPLETED.

2.5.0 WIRING TO THE GENERATOR

Unless specified otherwise, it is suggested that all cables be routed into the generator main cabinet through the wiring access panel on the rear of the cabinet. The cables should be secured to the lip on the access panel using tie wraps or equivalent fasteners.

All cables should be routed away from high voltage areas in the main cabinet, and dressed and secured neatly in place. Cables should be cut to the correct length if possible as excess cabling may contribute to EMI/RFI problems. For those cables that cannot be cut to the correct length (HT cables and console cables for example), try to minimize the area inside any loops of excess cable, as these loops are in effect an antenna.

EXCESS LENGTHS OF CABLING MUST NEVER BE BUNDLED UP AND STORED INSIDE THE GENERATOR.

2.5.0 WIRING TO THE GENERATOR (Cont)

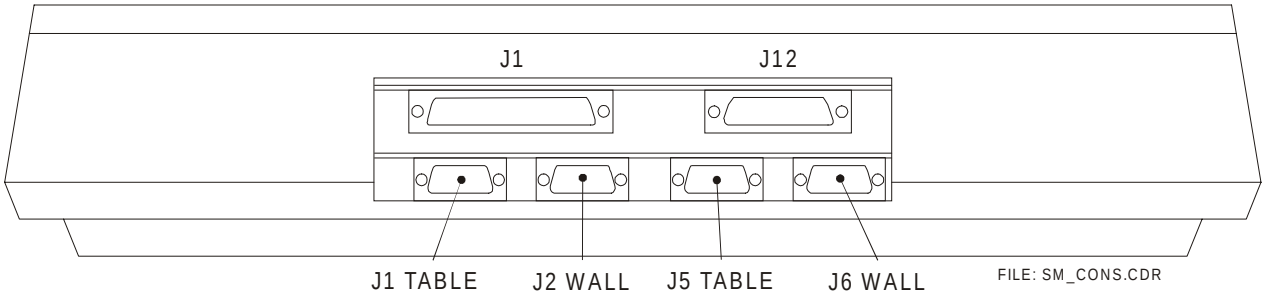
2.5.1 Control Console

1. Locate and unbundle the 37 conductor console cable. The free end of this cable is routed out of the generator main cabinet through the access panel on the rear of the cabinet. Connect the free end of this cable to J1 on the rear of the console. Ensure that the screw locks are fully tightened to secure the connector to the console. *For reference, the other end of this cable is connected to J1 on the power supply control board.*

2. Locate and unbundle the 25 conductor console cable. The free end of this cable is routed out of the generator main cabinet through the access panel on the rear of the cabinet. Connect the free end of this cable to J12 on the rear of the console. Ensure that the screw locks are fully tightened to secure the connector to the console. *For reference, the other end of this cable is connected to J6 on the customer interface board.*

3. Figure 2-2 shows the designations of the connectors on the rear panel of the control console.

Do not connect unapproved equipment to the rear of the console. J1 and J12 on the CPU board are used for the interconnect cables to the generator main cabinet. J1 and J2 on the AEC board are for conventional ion chamber AEC inputs, J5 and J6 are CAEC inputs used for special applications **only.** J1, J2, J5, and J6 are only available if the optional AEC board is fitted. AEC chamber compatibility must be confirmed per chapter 3. **INCORRECT CONNECTIONS OR USE OF UNAPPROVED EQUIPMENT MAY RESULT IN INJURY OR EQUIPMENT DAMAGE**.



J1, J2 ARE USED FOR CONVENTIONAL AEC CHAMBERS. J5, J6 ARE USED FOR CAEC CHAMBERS ONLY

Figure 2-2: Rear of control console

2.5.2 Handswitch (Optional)

The handswitch cable should be routed into the console via the cutout at the rear of the console. The handswitch connections are made to the J9 solder pads on the CPU board in the console. Pin assignments are as follows:

CPU BOARD	DEFINITION
J9-1	X-ray
J9-2	Prep
J9-3	Common

The handswitch cable should be dressed and secured as required to prevent strain on the terminations during normal use of the generator.

2.5.3 Stator Connections

Refer to figure 2-3 for the X-ray tube stator and thermal switch connections.

1. Route the X-ray tube stator cable to the stator terminal block. This is shown in figure 2-3.

USE OF A SHIELDED STATOR CABLE IS RECOMMENDED. THE SHIELD FOR THE STATOR CABLE MUST BE PROPERLY GROUNDED AT THE CHASSIS GROUND STUD SHOWN IN FIGURE 2-3.

2. Connect the wires to the stator terminal block as shown. The tube thermal switch will normally be connected to the THERMAL SWITCH connections on the stator terminal block, but may optionally be connected to the room interface board (refer to INPUTS in Chapter 3).

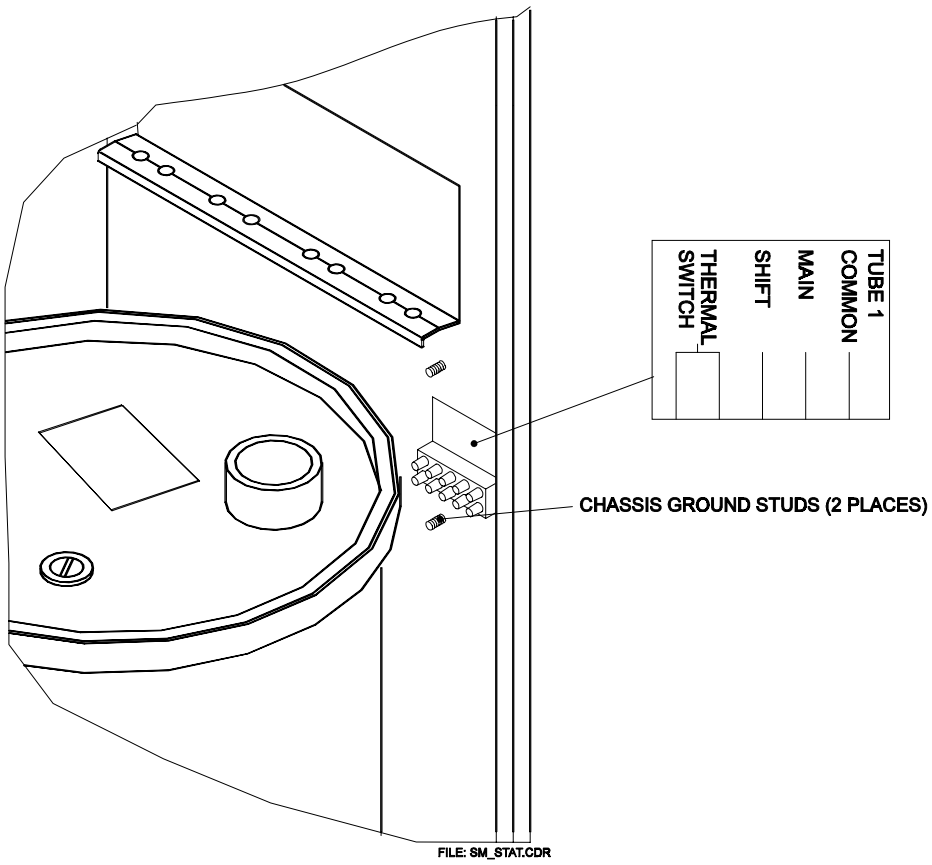


Figure 2-3: Stator connections to generator

STATOR LABEL DESIGNATIONS	TERMINAL DESIGNATIONS FOR SUMMIT TUBES ONLY
COMMON	09
MAIN	07
SHIFT	08
THERMAL SWITCH (Term 1)	T5
THERMAL SWITCH (Term 2)	T6

2.5.4 Thermal Switch

Refer to 2.5.3 for the X-ray tube thermal switch connections.

2.5.5 Power Line Mains

> ***WARNING:*** ***TO AVOID ELECTRICAL SHOCK, ENSURE THAT THE AC MAINS DISCONNECT IS LOCKED IN THE OFF POSITION, AND THAT ALL MAINS CABLES ARE DE-ENERGIZED BEFORE CONNECTING TO THE GENERATOR.***

Refer to Chapter 1 for generator power and generator power line requirements.

1. Pass the AC mains cable through the access hole located at the lower rear of the main cabinet.

2. Use an appropriate cable clamp to secure the mains cable at the cabinet entrance.

3. Temporarily remove the safety cover from the main fuses. Strip sufficient cable jacket to allow the ground wire to reach the main ground connector located at the left side of the main fuse block. Refer to figure 2-4.

4. Connect the ground wire to the chassis ground connector, and connect the mains power wires to the terminals on the bottom of the main fuse holder (3 wires for 3 phase systems, 2 wires for single phase systems as shown). Be sure to replace the main fuse safety cover after all connections are made and properly tightened.

5. DO NOT SWITCH ON MAINS POWER AT THIS TIME.

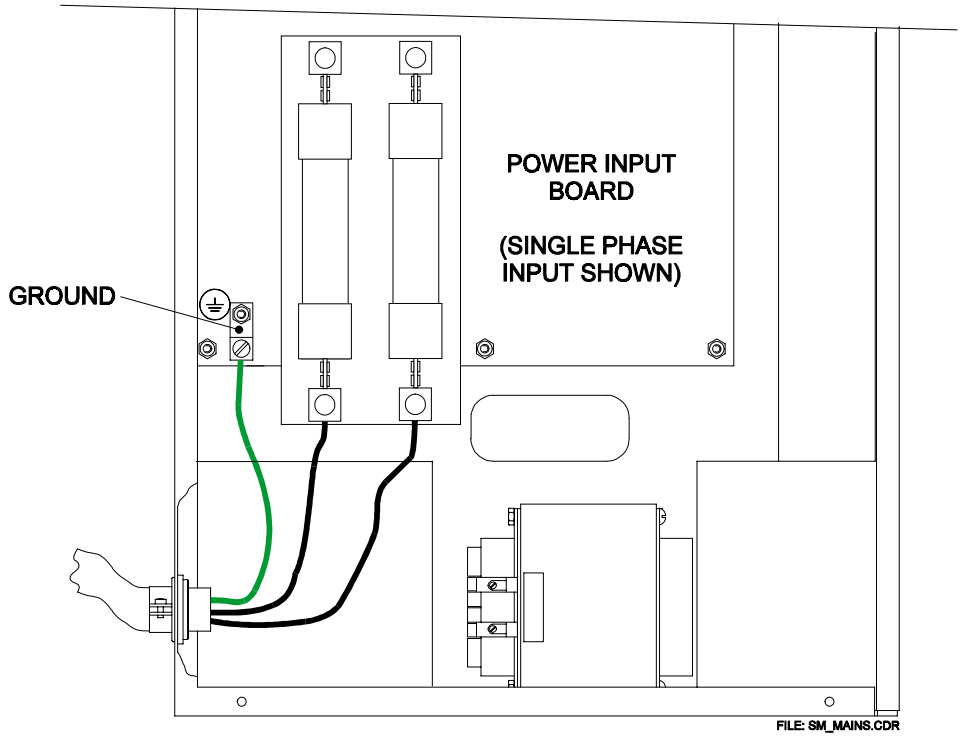


Figure 2-4: Generator mains connection

2.5.6 High Tension Cables

The X-ray tube should be mounted in its normal fixture i.e. tube stand or other device.

1 Verify that the HT cable terminations are clean, in good condition, and coated with vapor proof compound.

2. Remove the dust caps which cover the high voltage terminals on the HT oil tank.

3. Connect the anode and cathode cables to the HT tank. Use the right angle connectors for the HT transformer end. Ensure that the cables are plugged into the proper connectors on the HT tank. Refer to figure 2-5.

4. Be sure that the HT cable connectors are tight and there is ***no play between*** the connector insulator and the screw down ring.

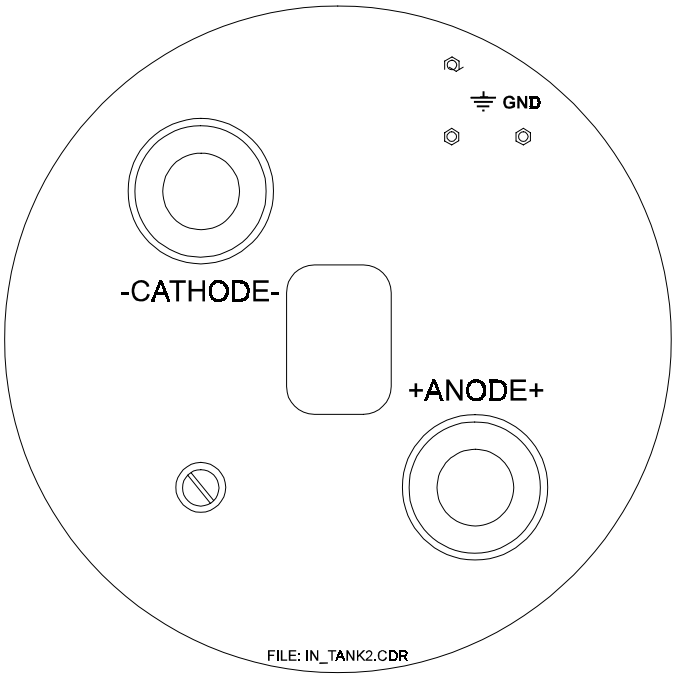


Figure 2-5: HV connector identification

2.5.7 X-Ray Tube Housing Ground

A separate ground wire (10 AWG, 6mm^2) must be connected from the X-ray tube housing to one of the ground studs on the HT tank. Refer to figure 2-5 for the location of these ground studs. These ground locations may have other ground wires already connected, ensure that these existing ground wires are not disconnected when making the X-ray tube ground connection.
Failure to make this ground connection may result in intermittent operation and/or exposure errors.

2.5.8 Room Equipment

Refer to Chapter 3 for connection of the Buckys, interlocks, collimator lamp and system locks power, and optional AEC chambers. It is suggested that these items not be connected until after the initial run-up of the generator is complete, and the tube auto calibration routine has been performed as described near the end of this Chapter.

2.5.9 Safety Interlocks

The room door interlock switch must be wired to the generator as described in INPUTS in Chapter 3 prior to power up. This switch will provide a closed contact when the door is closed.

2.6.0 INITIAL RUN-UP

This section describes the procedure for initial power-on of the generator after it has first been installed.

2.6.1 Initial Voltage Measurements

1. Verify that the mains voltage and current capacity is correct for the generator installation per GENERATOR POWER REQUIREMENTS in Chapter 1 of this manual.

2. Temporarily remove the safety cover over the main input fuses in the generator.

3. If the mains supply is compatible with the generator, switch on the main breaker and/or disconnect switch and check for the following voltages:

NOTE:	***DO NOT SWITCH THE GENERATOR ON AT THIS TIME (ONLY THE AC MAINS TO THE GENERATOR IS TO BE SWITCHED ON).***

WARNING:	***USE EXTREME CARE IN MEASURING THESE VOLTAGES. ACCIDENTAL CONTACT WITH MAINS VOLTAGES MAY CAUSE SERIOUS INJURY OR DEATH.*** ***MAINS VOLTAGE WILL BE PRESENT INSIDE THE GENERATOR CABINET, EVEN WITH THE CONSOLE SWITCHED OFF.*** ***THE DC BUS CAPACITORS, LOCATED ON THE DC BUS ASSEMBLY PRESENT A SAFETY HAZARD FOR A MINIMUM OF 5 MINUTES AFTER THE GENERATOR HAS BEEN SWITCHED OFF. CHECK THAT THESE CAPACITORS ARE DISCHARGED BEFORE TOUCHING ANY PARTS IN THE GENERATOR.***

4. Measure and record the line voltage across the line fuses in the generator.
   Line voltage = _____ VAC.

5. Is the line voltage within specification for the unit as per Chapter 1?
   ___ Check.

6. Switch OFF the mains power to the generator. Verify that there is no line voltage present, then replace the safety cover on the main input fuse block.

1.6.0 INITIAL RUN-UP (Cont)

7. Switch the mains power ON again, then switch the generator ON at the console.

8. Verify that the red LED (DC BUSS OK) located on the power input board in the main cabinet is lit.
   ___ Check.

9. Switch off the generator, then switch back ON after approximately 10 seconds. Observe the startup sequence on the console APR display.

   - The generator type / model may be briefly displayed.
   - The software revision will be shown while the console runs a series of diagnostic tests.

10. Verify that the following LED's on the auxiliary board in the main cabinet are lit:

D2	CNTCTR CLSD
D3	S.S. OK
D29	+12V
D30	-12V
D31	+/- 35V

2.7.0 TUBE MA AUTO CALIBRATION

The X-ray tube may be auto calibrated without completing the room interface connections. Before being able to make X-ray exposures, the room door interlock must be closed and the thermal switch must be closed.

Refer to Chapter 3 for the procedure for performing the X-ray tube auto calibration.

2.8.0 FINAL CHECKS

- The room interface connections may now be completed. These items are described in 2.5.8.
- When finished all wiring, check that all connections are tight and secure.
- Check that all cables are dressed neatly inside the main cabinet, and secured as necessary.
- Reconnect any grounds that have been removed from covers. Then reinstall all covers before placing the generator into service.

2.9.0 UTILITY SOFTWARE

The optional CPI utility software allows for data communication between the console and an external computer. This provides a "virtual storage oscilloscope" that displays key waveforms and displays data not otherwise available, and allows uploading and downloading of EEPROM, tube, and APR data. It also allows editing of film / screen names and APR text.

A computer with an RS-232 port (i.e. laptop) and a serial cable are required to run the utility software and to interface to the console. The serial cable to connect to the console is a special cable that must be ordered from the factory. The part number of this cable to order is 735184-00.

CHAPTER 3

INTERFACING, PROGRAMMING, AND CALIBRATION

CONTENTS:

3.1.0 INTRODUCTION 3-2
3.2.0 WIRING TO INPUTS & OUTPUTS 3-2
3.2.1 Inputs 3-2
3.2.2 Outputs 3-3
3.2.3 Inputs & Outputs (simplified schematic) 3-4
3.2.4 AEC Interconnect 3-5
3.2.5 AEC Left / Right (Field 1 / Field 2) Reversal 3-6
3.3.0 GENERATOR PROGRAMMING 3-7
3.3.1 Generator Utility Functions (overview) 3-7
3.4.0 LEVEL 1 UTILITIES 3-7
3.4.1 APR Save 3-8
3.4.2. Date and Time 3-9
3.4.3. Exit 3-9
3.4.4 Utilities 3-9
3.5.0 LEVEL 2 UTILITIES 3-9
3.5.1 Calibration 3-11
3.5.2 AEC Adjustment 3-11
3.5.3 Focus Disable 3-11
3.5.4 Exp. Counter 3-12
3.5.5 LCD mode 3-12
3.5.6 Configuration 3-12
3.5.7 Tube Selection 3-13
3.5.8 Receptor Conf. 3-14
3.6.0 HARDWARE PROGRAMMING 3-14
3.6.1 Speaker Volume 3-14
3.6.2 LCD Backlight Brightness adjustment 3-15
3.7.0 AEC PROGRAMMING AND CALIBRATION 3-16
3.7.1 AEC Limitations: Minimum and Maximum Exposure Times 3-16
3.7.2 Precalibration Notes 3-16
3.7.3 Navigating the AEC Adjustment menus 3-17
3.7.4 AEC Calibration (Table Bucky) 3-17
3.7.5 AEC Calibration (Wall Bucky) 3-22

3.1.0 INTRODUCTION

This Chapter describes the interfacing of the generator to the Bucky(s), interlocks, collimator lamp and tube stand locks, and to the AEC chambers if the AEC option is fitted. Programming and AEC calibration of the generator is also described in this Chapter.

3.2.0 WIRING TO INPUTS & OUTPUTS

NOTE: ***THE INSTALLER MUST PROVIDE THE NECESSARY INTERFACING CABLES FOR WIRING TO THE GENERATOR INPUTS AND OUTPUTS DESCRIBED IN THIS SECTION.***

WARNING: ***LINE VOLTAGE IS PRESENT INSIDE THE GENERATOR AT ALL TIMES THAT THE MAIN DISCONNECT IS SWITCHED ON. FOR SAFETY, THE MAIN DISCONNECT SHOULD BE SWITCHED OFF AND LOCKED OUT WHILE CONNECTING ROOM EQUIPMENT.***

3.2.1 Inputs

The Bucky inputs, S.I.D. interlocks, room door interlock, and thermal switch inputs are opto coupled. This means that a relay contact, transistor, or other low impedance ($\leq$ 100 Ω, 10 mA current rating) switching device must be connected across each of those inputs. Table 3-1 below defines the pinouts, polarity at the terminals and the logic condition required for that input. If using a directional switching device, such as a transistor, the polarity of the voltage seen by the switching device must be observed. This is shown in the table below.

Refer also to figure 3-1. This is a pictorial drawing of the Bucky inputs and outputs, the interlock inputs, and the thermal switch inputs.

Refer to 3.2.4 for details on AEC connections.

WARNING: ***DO NOT DEFEAT THE 40″ OR 72″ S.I.D. INTERLOCKS, OR THE ROOM DOOR INTERLOCK UNLESS THE CORRESPONDING DEVICE IS NOT PRESENT. CONSULT THE APPLICABLE REGULATIONS BEFORE BYPASSING ANY EXPOSURE INTERLOCKS. DO NOT VIOLATE ANY REGULATIONS FOR X-RAY SAFETY.***
NEVER BYPASS THE X-RAY TUBE THERMAL SWITCH INTERLOCK.
OBSERVE IONIZING RADIATION PERSONAL PROTECTION AT ALL TIMES.

3.2.1 Inputs (Cont)

NOTE: ***IN THIS MANUAL, THE WALL BUCKY IS REFERRED TO AS BUCKY 1, AND THE TABLE BUCKY IS BUCKY 2.***

CUSTOMER INTERFACE BOARD	DEFINITION
J2-5 (+) J2-6 (-)	B1: Bucky 1 ready. A contact closure from pin 5 to 6 indicates B2: BUCKY 1 READY.
J3-5 (+) J3-6 (-)	B1: Bucky 2 ready. A contact closure from pin 5 to 6 indicates B2: BUCKY 2 READY.
J3-1 (+) J3-2 (-)	Door interlock. A contact closure from pin 1 to 2 is required to make an exposure. This indicates that the room door is closed.
J2-7 (+) J2-8 (-)	40 inch (100 cm) S.I.D. interlock. A contact closure from pin 7 to 8 indicates the tube is at a 40 inch (100 cm) S.I.D.
J2-9 (+) J2-10 (-)	72 inch (180 cm) S.I.D. interlock. A contact closure from pin 9 to 10 indicates the tube is at a 72 inch (180 cm) S.I.D.
J3-4 (+) J3-3 (-)	Thermal switch. A contact closure from pin 4 to 3 is required to make an exposure. This indicates normal operation of the X-ray tube.

Table 3-1: Generator inputs

3.2.2 Outputs

Table 3-2 shows the Bucky and auxiliary power outputs from the generator. Refer also to figure 3-1.

CUSTOMER INTERFACE BOARD	DEFINITION
J2-1	B4: 110 VAC return (Bucky 1).
J2-2	B6: Ground (Bucky 1).
J2-3	B8: 110 VAC out (Bucky 1).
J2-4	B3: 110 VAC out (Bucky 1 start).
J3-7	B4: 110 VAC return (Bucky 2).
J3-8	B6: Ground (Bucky 2).
J3-9	B8: 110 VAC out (Bucky 2).
J3-10	B3: 110 VAC out (Bucky 2 start).
J4-1 J4-2	24 VAC @ 150 watts output for collimator light (unswitched). *This output is rated for intermittent (collimator lamp) duty only, <10% duty cycle.*
J4-5 (+) J4-6 (-)	24 VDC @ 45 watts output for tube stand locks (unswitched).

Table 3-2: Generator outputs

3.2.3 Inputs & Outputs (simplified schematic)

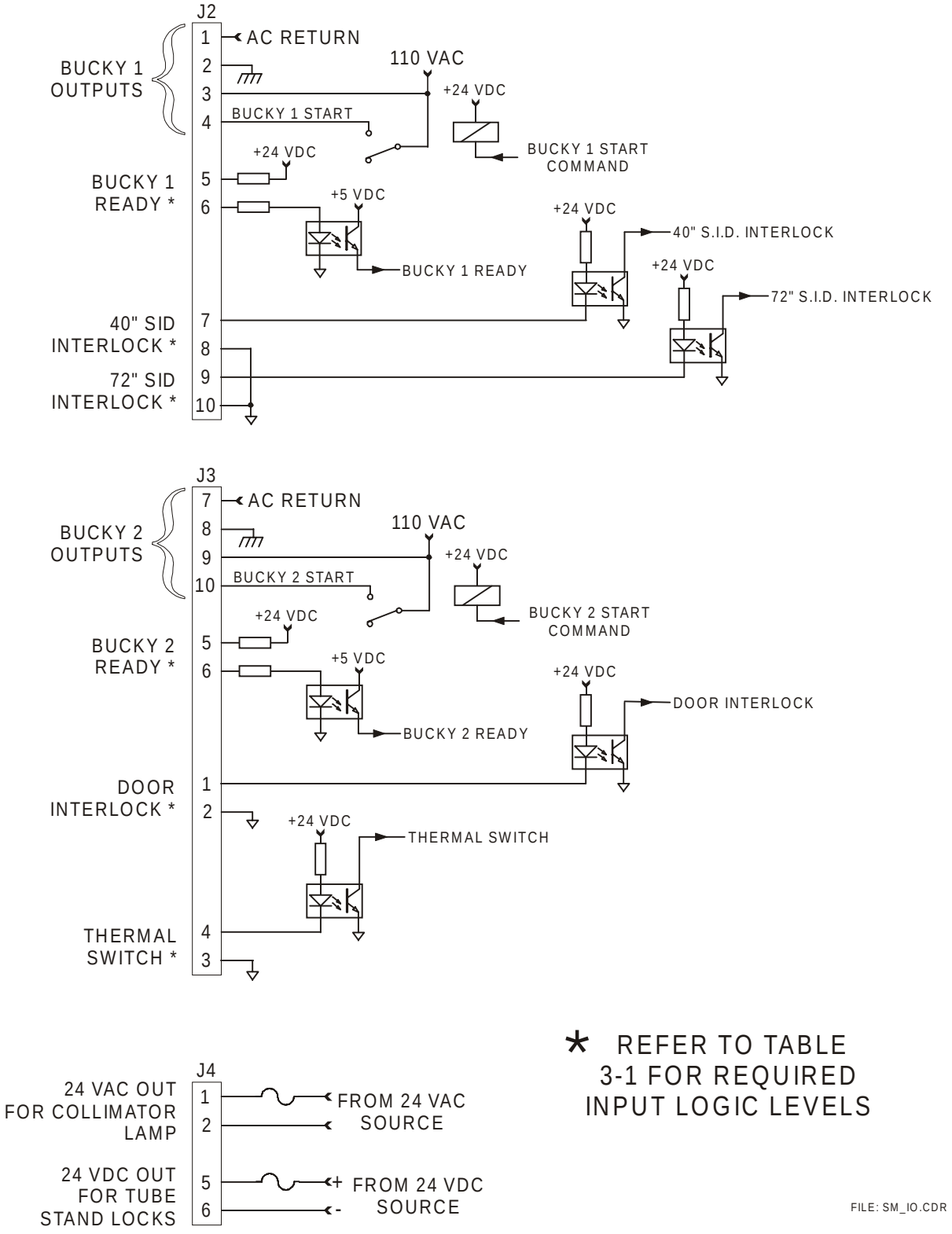


Figure 3-1: J2, J3, J4 inputs and outputs (customer interface board)

3.2.4 AEC Interconnect

NOTE: ***IF YOUR GENERATOR USES "CAEC" AEC CHAMBER(S), REFER TO SEPARATE SUPPLEMENT AT FRONT OF THIS MANUAL IN CONJUNCTION WITH THIS MANUAL.***

Table 3-3 and figure 3-2 show the functions and signals at each pin of the AEC connectors J1 and J2 on the AEC board in the console. The AEC connections are directly compatible with A.I.D. ion chambers as listed in section 3.2.5.

AEC BOARD (J1 TABLE, J2 WALL)	DEFINITION
Pin 1	No connection.
Pin 2	Field select 2 (configuration A) as shipped from the factory. This is configurable to select field 1 if required, refer to 3.2.5.
Pin 3	Field select 1 (configuration A) as shipped from the factory. This is configurable to select field 2 if required, refer to 3.2.5.
Pin 4	Reset / start.
Pin 5	AEC input signal from chamber.
Pin 6	Field select 3.
Pin 7	-15 VDC to chamber.
Pin 8	+15 VDC to chamber.
Pin 9	Ground.

Table 3-3: AEC board inputs / outputs

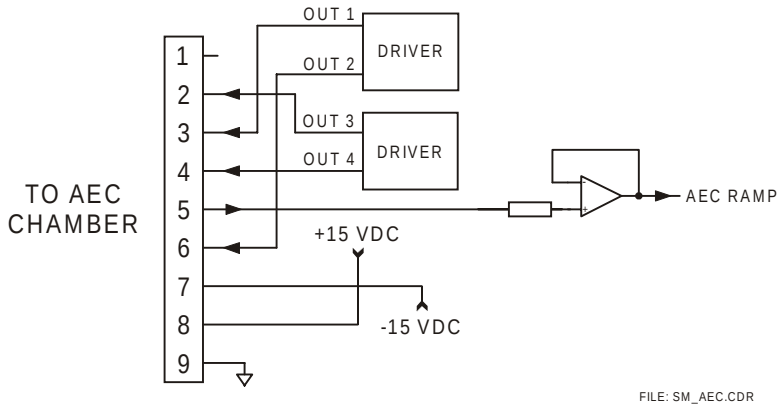


Figure 3-2: AEC interconnect (simplified schematic)

3.2.5 AEC Left / Right (Field 1 / Field 2) Reversal

Most A.I.D. AEC chamber models designate the left field as field 2, and the right field as field 1. For a few A.I.D. AEC chamber models, this convention is reversed. Refer to figure 3-3 and table 3-4.

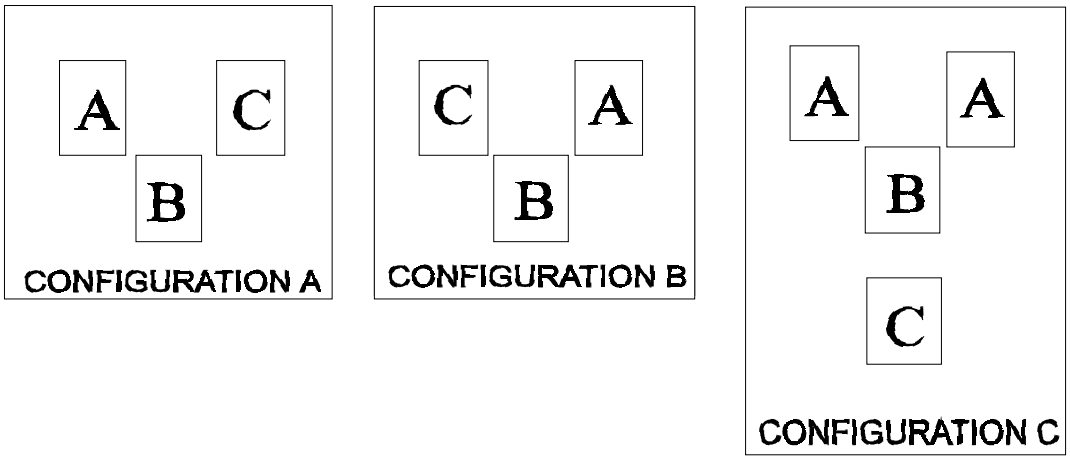


Figure 3-3: AEC chamber configurations

A.I.D. CHAMBER MODEL	CONFIGURATION
ICX153,159,162,181,192	Configuration A
If AEC Device Is Installed 180°	Configuration B
ICX181	Configuration C

Table 3-4: A.I.D. ion chamber identification

The AEC board must be configured such that field select 1 and field select 2 correctly select the left and right fields for both chamber configurations. This is done by inserting jumpers on the AEC board per table 3-5. Please confirm that these jumpers are correctly installed to match the chamber type in use.
BOTH AEC CHAMBERS MUST BE CONFIGURATION A, OR CONFIGURATION B. THE AEC BOARD WILL NOT SUPPORT A MIX OF CONFIGURATION A AND CONFIGURATION B AEC CHAMBERS

CONFIGURATION	AEC BOARD JUMPERS
Configuration A	JW3, JW4
Configuration B	JW5, JW6

Table 3-5: A.I.D. ion chamber identification

NOTE: ***DO NOT JUMPER ANY COMBINATIONS OTHER THAN JW3 AND JW4, OR JW5 AND JW6. DO NOT REMOVE OR RECONFIGURE ANY OTHER FACTORY INSTALLED JUMPERS ON THE AEC BOARD.***

3.3.0 GENERATOR PROGRAMMING

Programming of the generator is performed using the operator console. All programming menus are displayed in the LCD display window on the console. The nine "soft key" buttons (1 to 9 in the figure below) are used to navigate through the programming screens and to select and enter values in this section.

In this section, ***SELECT*** means to press the button adjacent to the desired function shown in the LCD display window. ***TOGGLE*** means to press the stated button repeatedly to cycle through the available selections.

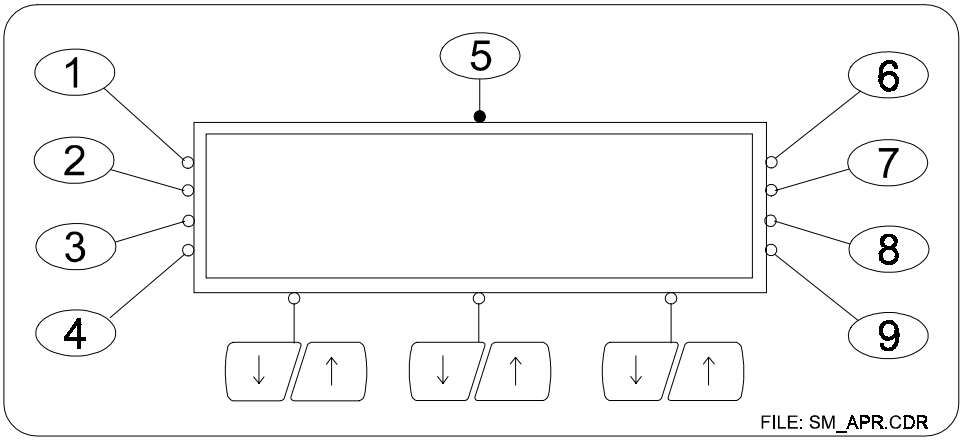


Figure 3-4: Programming / calibration mode reference

3.3.1 Generator Utility Functions (overview)

This X-ray generator has two levels of utility functions. The level 1 utilities are available to the operator, and include minor functions such as setting the clock and enabling / disabling the APR editing function. Level two utilities are password protected and include setup and calibration functions.

3.4.0 LEVEL 1 UTILITIES

To access the level 1 utilities follow the steps below:

Step	Action	Result
1.	Start with the generator switched OFF.	
2.	Press and hold the menu button [**5**] while pressing the POWER ON button on the console until the console beeps, (approximately 10 seconds).	The generator will go through its start-up sequence, then display the screen shown below. This is the level 1 utility menu. The PREP and X-RAY LEDs are briefly lit during the console start-up sequence. This is a diagnostic test, and allows confirmation that the LEDs are functional.
3.	If an error message is presented after the start-up sequence, press **OK** and / or **RESET** to access the level 1 utility menu.	

3.4.0 LEVEL 1 UTILITIES (Cont)

The level 1 utility menu presents the user with 4 options.

*In most cases, pressing the menu button [**5**] will return to the previous screen or the previous menu. This will assist in navigating through the screens in this section.*

The table below shows the functions available within each of the options in the level 1 utility menu.

APR SAVE OFF	• Enables/disables the ability to *make and then save* changes to APR techniques (kV, mA etc, but ***NOT*** APR text changes).
DATE & TIME	• Allows setting of the date and time.
EXIT	• Returns to normal operating mode (non setup / programming mode).
UTILITIES	• Accesses the level 2 utility functions.

3.4.1 APR Save

Use these steps to enable / disable the ability to *make and then save changes* to APR techniques:

Step	Action
1.	From the level 1 utility menu select **APR SAVE OFF.** This is the default when the generator is switched on, the display will show **APR SAVE ON** if the APR save function has subsequently been changed to ON.
2.	In the APR EDIT AND SAVE CONTROL screen, a prompt **APR SAVE OFF** will display. Press the adjacent button to toggle the selection of **APR SAVE OFF** or **APR SAVE ON**. When the desired APR edit mode is selected, press the menu button [**5**] to return to the level 1 utility menu.
3.	With **APR SAVE ON**, press **EXIT** to return to the main APR screen.
4.	The procedure for making changes to the APR when in the normal operating mode is described in the operator's manual.
5.	To reset the **APR SAVE ON** mode**,** switch the console OFF, then ON again. This will disable the ability to make further APR changes until the APR SAVE mode is subsequently enabled.

3.4.0 LEVEL 1 UTILITIES (Cont)

3.4.2. Date and Time

Use these steps to set the date and time:

Step	Action
1.	From the level 1 utility menu select **DATE & TIME.**
2.	Press ← or → to select the parameter to change (month, day, year, hour, or minute). The selection over the caret symbol **^** is the parameter that will be set in the next step.
3.	Press **UP** or **DOWN** to set the selected parameter. Time is set in 24 hour mode.
4.	Repeat steps 2 and 3 to set the remaining parameters. Note that the time does not increment when in the setup utility.
5.	Press the menu button [**5**] to return to the main level 1 utility screen.

3.4.3. Exit

Use this step to access the APR menu. This is the console normal operating mode.

Step	Action
1.	From the level 1 utility menu select **EXIT.** The console will enter the normal operating mode.

3.4.4 Utilities

Use these steps to access the level 2 utilities:

Step	Action
1.	From the level 1 utility menu select **UTILITIES.**
2.	Enter the password at the prompt by pressing the button sequence [**1**], [**2**], [**3**], [**4**]. Refer to figure 3-4.
3.	A security screen will be presented. Select **EXIT** to return to the main level 1 utility screen. Select **ACCEPT** to display the main level 2 utility screen as per 3.5.0.

3.5.0 LEVEL 2 UTILITIES

To access the level 2 utilities follow the steps in 3.4.4. The first screen of the level 2 utilities will be displayed.

The level 2 utility menus present the user with 16 options. Screen 1 of the level 2 utilities is shown below:

CALIBRATION	EXP. COUNTER
AEC ADJUSTMENT	[MORE]
EXPOSURE LOG	
FOCUS DISABLE	

3.5.0 Level 2 Utilities (Cont)

Press **[MORE]** on the above screen to access screen 2 of the level 2 utilities, shown below:

LCD MODE	FILM SPEED
CONFIGURATION	[MORE]
TUBE SELECTION	
FILM PROGRAM	

Press **[MORE]** on the above screen to access screen 3 of the level 2 utilities, shown below:

MAS STEP SIZE
RECEPTOR CONF.
TUBE SEASONING

The table below shows the functions available within the level 2 utility menus.

CALIBRATION	• Selects the tube auto calibration routine.
AEC ADJUSTMENT	• Selects AEC calibration mode.
EXPOSURE LOG	• This function is not available.
FOCUS DISABLE	• Disables one or both focal spots.
EXP. COUNTER	• Accesses the exposure counter.
[MORE]	• Accesses screen 2 of the level 2 utilities.
LCD MODE	• Selects normal or reverse video for the LCD display.
CONFIGURATION	• Allows the AEC function to be enabled or disabled. Also allows setting of AEC type (if used), setting of maximum kV, and setting of maximum output power (some models).
TUBE SELECTION	• Allows the desired X-ray tube to be selected. Selecting a new X-ray tube erases the tube calibration data.
FILM PROGRAM	• This function is not available.
FILM SPEED	• This function is not available.
[MORE]	• Accesses screen 3 of the level 2 utilities
MAS STEP SIZE	• This function is not available.
RECEPTOR CONF.	• Allows programming of the wall or table receptors.
TUBE SEASONING	• This function is not available.

3.5.1 Calibration

The calibration function automatically establishes calibration curves relating filament current to tube current (mA) at three or four kV settings, depending on generator type. This allows the generator to predict the filament temperature (filament current) that will be required for any mA value over the full kV operating range.

It is recommended that the X-ray tube be seasoned before attempting auto calibration, particularly if the tube has not been used for some time. Refer to Chapter 6 for the procedure to do this.

Use these steps to perform the X-ray tube auto calibration function:

Step	Action
1.	Ensure that the correct X-ray tube type is selected before beginning X-ray tube auto calibration. Refer to TUBE SELECTION in this Chapter to select the tube type. Ensure compatibility of the tube stator with the generator before proceeding, and verify all stator connections.
2.	From the level 2 utility menus select **CALIBRATION.**
3.	Select the focal spot to calibrate. Start with small (SM FOCUS).
4.	Press and hold the X-ray button (or use the optional handswitch) to begin the calibration procedure.
5.	When calibration is finished on the selected focal spot, **COMPLETE..** will be displayed. Release the exposure switch at this point.
6.	Select the next focal spot to calibrate and repeat steps 4 and 5.
7.	Should the exposure switch be released before auto-calibration is complete, an error message will be presented. Exposures are not permitted on a tube which has not been calibrated on the selected focal spot.
8.	Press the menu button [**5**] to return to screen 1 of the level 2 utility screens.

3.5.2 AEC Adjustment

Refer to AEC PROGRAMMING AND CALIBRATION at the end of this Chapter for the AEC calibration procedure. Tube auto calibration must be completed before attempting AEC calibration.

Exposure Log

This function is not available.

3.5.3 Focus Disable

This function provides the ability to disable focal spots should one of the filaments in the X-ray tube become damaged in the field. If both focal spots are disabled, an error message will be displayed.

Use these steps to disable focal spot(s):

Step	Action
1.	From the level 2 utility menus select **FOCUS DISABLE.**
2.	Select **DISABLE SF** to disable the small focus. Select **DISABLE LF** to disable the large focus. The ENABLED / DISABLED status of each focal spot is shown on the left side of the LCD display during this programming step, and also during start up of the generator.
3.	Press the menu button [**5**] to return to screen 1 of the level 2 utility screens.

3.5.4 Exp. Counter

This function allows the number of exposures taken on each focal spot of the X-ray tube to be viewed.

Use these steps to view the exposure counter:

Step	Action
1.	From the level 2 utility menus select **EXP. COUNTER.**
2.	The exposure count for the small focus (**SF**) and large focus (**LF**) may be viewed on the LCD display.
3.	Press the menu button [**5**] to return to screen 1 of the level 2 utility screens.

[More]

This accesses screen 2 of the level 2 utilities.

3.5.5 LCD mode

This function allows setting of normal or reverse video on the LCD display.

Use these steps to set the normal or reverse video:

Step	Action
1.	From the level 2 utility menus select **LCD MODE.**
2.	Select **NORMAL** for normal video, or **INVERSE** for reverse video.
3.	Press the menu button [**5**] to return to screen 2 of the level 2 utility screens.

3.5.6 Configuration

This function allows global enabling or disabling of the AEC function, setting of the optional AEC type, setting of the maximum kV, and in some models setting of the maximum generator output power.

Use these steps to set the above parameters:

Step	Action
1.	From the level 2 utility menus select **CONFIGURATION.**
2.	Toggle button [**1**], to select **AEC INHIBITED** if the AEC function is to be disabled. This is normally selected if the optional AEC board is not fitted. Select **ION CHAMBER AEC** for three field ion chamber(s), or **1 FIELD ION AEC** for single field ion chamber(s).
3.	Press the **KV MAX: UP** button to increase the maximum kV. Press the **DOWN** button to decrease the maximum kV. The maximum kV may be adjusted between the limits of 80 and 125 kV or 80 to 150 kV depending on application.
4.	**DENSITY** selection is not available.
5.	Select **30kW, 32.5kW,** or **37.5kW** for 1 phase generators, or **50kW** for 3 phase 50 kW generators. Some single phase models will only allow the selection of 30 kW. Where selection of 32.5 and 37.5 kW ***IS*** available in the generator, the line voltage must be within the range of 230 to 253 volts AC. This function is not available on all models.
6.	Press the menu button [**5**] to return to screen 2 of the level 2 utility screens.

3.5.7 Tube Selection

This function allows the desired X-ray tube to be selected from those displayed on the console. Other tube types may be available by downloading new tube data to the EEPROM on the CPU board.

Use these steps to select the desired X-ray tube:

Step	Action
1.	From the level 2 utility menus select **TUBE SELECTION.**
2.	Select the desired tube by pressing the adjacent button. The selected tube type will be enclosed within the **>** and **<** symbols. ***NOTE THAT CHANGING THE TUBE TYPE WILL ERASE EXISTING CALIBRATION DATA.***
3.	Press the menu button [**5**] to return to screen 2 of the level 2 utility screens.

Film Program

This function is not available.

Film Speed

This function is not available.

[MORE]

This accesses screen 3 of the level 2 utilities.

MAS STEP SIZE

This function is not available.

3.5.8 Receptor Conf.

This function allows the wall and table image receptors to be programmed. For each of these receptors, AEC may be ENABLED or DISABLED, and the wall Bucky or table Bucky may be ENABLED or DISABLED.

If the wall or table Bucky is ENABLED, the wall or table Bucky selector(s) may be selected *AND* the generator will look for a Bucky ready signal. If the wall or table Bucky is DISABLED, the wall or table Bucky selector(s) may be selected *BUT* the generator will not require a Bucky ready signal to make an exposure. This selection is typically made if a grid cabinet is used.

Use these steps to program the image receptors:

Step	Action
1.	From the level 2 utility menus select **RECEPTOR CONF.**
2.	Toggle button [**3**] to select **AEC: ENABLED** or **AEC: DISABLED** for the wall Bucky. **DISABLED** will not allow AEC to be selected for the wall Bucky.
3.	Toggle button [**4**] to select **BUCKY: ENABLED** or **BUCKY: DISABLED** for the wall Bucky. **DISABLED** means that the generator will not require a Bucky ready signal to make an exposure.
4.	Toggle button [**8**] to select **AEC: ENABLED** or **AEC: DISABLED** for the table Bucky. **DISABLED** will not allow AEC to be selected for the table Bucky.
5.	Toggle button [**9**] to select **BUCKY: ENABLED** or **BUCKY: DISABLED** for the table Bucky. **DISABLED** means that the generator will not require a Bucky ready signal to make an exposure.
6.	Press the menu button [**5**] to return to screen 3 of the level 2 utility screens.

TUBE SEASONING

This function is not available.

3.6.0 HARDWARE PROGRAMMING

3.6.1 Speaker Volume

The speaker in the console may be set to one of three loudness levels. To change the current speaker volume, perform the following steps.

step	Action
1.	Switch the generator OFF at the console.
2.	Turn the console on its face. A soft, clean cloth should be placed on the work surface to protect the console from damage while it is face down.
3.	Remove and temporarily set aside the screws at the bottom of the console. Carefully remove the bottom of the console enclosure.
4.	Locate JW3 and JW4 on the CPU board in the console. These are near the speaker LS1 at the bottom of the CPU board.
5.	Insert or remove jumpers JW3 and JW4 per the table below for the desired speaker volume.
6.	Both jumpers are installed when shipped from the factory. If one or both jumpers is removed to reduce the speaker volume, it is suggested that they be stored in a safe place in case they need to be reinstalled at a later time.
7.	Reposition the console bottom and replace the hardware that was removed in step 3.

3.6.1 Speaker Volume (Cont)

JW3, JW4	VOLUME
JW3 and JW4 removed	Low
JW3 ***or*** JW4 installed	Medium
JW3 and JW4 installed	High

3.6.2 LCD Backlight Brightness adjustment

The brightness of the LCD display may be adjusted as desired. To change the LCD brightness, perform the following steps.

step	Action
1.	Follow steps 1 to 3 in section 3.6.1.
2.	Locate R2 on the CPU board. Refer to figure 6-2 (Chapter 6).
3.	Switch ON the console and observe the LCD display brightness. ***TAKE ALL APPROPRIATE PRECAUTIONS WITH THE CONSOLE SWITCHED ON. HIGH VOLTAGE IS PRESENT IN THE AREA OF THE LCD BACKLIGHT AND THE LCD BACKLIGHT POWER SUPPLY.***
4.	Adjust R2 to set the desired LCD brightness.
5.	Switch OFF the console.
6.	Reposition the console bottom and replace the hardware that was removed in previous steps.

3.7.0 AEC PROGRAMMING AND CALIBRATION

This section applies to generators with optional AEC only.

This section contains background information relevant to AEC operation. It is strongly suggested that this be read and understood prior to beginning AEC calibration.

3.7.1 AEC Limitations: Minimum and Maximum Exposure Times

- Due to various delays inherent in the AEC chamber and generator electronics, minimum AEC exposure times should be greater than 10 ms.
- AEC exposures should normally be kept well under one second. When X-ray techniques are used that result in longer exposures, the film density will not be correct due to film reciprocity failure.
- Care must be exercised when using low kV values with table Buckys because most table tops and grids absorb considerable radiation in the range of 60 - 65 kVp. This will adversely affect AEC operation.

3.7.2 Precalibration Notes

Please note the following points before beginning AEC calibration:

- ***All setup functions per the preceeding sections must be completed before beginning AEC calibration.***
- The generator must be known to be calibrated before beginning AEC calibration.
- All components (X-ray tubes, collimators, AEC chambers, etc) used during AEC calibration must be those which will be used during procedures, and must be positioned as they will be in actual use of the X-ray room.
- During AEC calibration, always ensure that the central ray is centered relative to the image receptor.
- Prior to placing the water absorber, ensure that the collimator is opened sufficiently to cover ALL fields on the AEC pickup device.
- Ensure that the absorber is positioned such as to fully cover the X-ray field. The absorber must extend a minimum of 3/8″ (10 mm) beyond the X-ray field.
- The AEC chamber(s) must be calibrated, and the AEC fields must be balanced before proceeding. This should be done per the AEC chamber manufacturers procedure.
- AEC calibration is performed using the center field only, (left and right fields are not selectable during AEC calibration).
- A maximum of three separate AEC calibration curves may be established (for three film screen combinations). Each AEC calibration curve has five breakpoints, normally 55 kVp, 65 kVp, 80 kVp, 100 kVp, and 125 kVp. These are the factory defaults referenced in the following steps, but may be changed if required by pressing kVp ↑ or ↓.
- AEC breakpoint calibration is initially performed for film / screen combination 1, displayed when entering the AEC ADJUSTMENT menu. When this is complete, AEC calibration may be performed for the next film / screen combination. The third and last film / screen combination is calibrated next, if desired.
- The labels for the three film screen combinations may be set to the site requirements using a laptop computer and the Service Software. In this procedure, the three film screen combinations will be referred to as F/S 1, F/S 2, and F/S 3 (film / screen 1, film / screen 2, and film / screen 3).

3.7.3 Navigating the AEC Adjustment menus

The first screen displayed within the **AEC ADJUSTMENT** menu will show breakpoint #1, normally 55 kVp, for F/S 1. Pressing → will scroll through the F/S 1 kVp breakpoints in the sequence 55, 65, 80, 100, and 125 kVp.
Pressing → again will change to F/S 2, starting with the 55 kVp breakpoint. Continuing to press → will scroll through the breakpoints for F/S 2.
Pressing → again will change to F/S 3, starting with the 55 kVp breakpoint. Continuing to press → will scroll through the breakpoints for F/S 3.
Pressing → again starts the above cycle over, pressing ← reverses the above sequence.
Pressing **GAIN ADJ** when requested opens a submenu which allows setting of the AEC gain for F/S 1, F/S 2, and F/S 3.

3.7.4 AEC Calibration (Table Bucky)

CAUTION: ***THE PROCEDURES IN THESE SECTIONS REQUIRE X-RAY EXPOSURES. TAKE ALL SAFETY PRECAUTIONS TO PROTECT PERSONNEL FROM X-RADIATION.***

The following is an overview of the steps that will be performed in sections 3.7.4 and 3.7.5.

- Set up the equipment in preparation for table bucky AEC calibration, including water phantom absorbers.
- Set the AEC reference to a mid value at the 80 kVp knee breakpoint for film / screen 1. Adjust the AEC gain to achieve the correct film density.
- Once the AEC gain is correctly set at the 80 kVp knee breakpoint, set the correct film density at 55 kVp, 65 kVp, 100 kVp, and 125 kVp by adjusting the AEC reference at each of those breakpoints.
- Repeat the previous two steps for film / screen 2 and film / screen 3, if used, ***except*** the density adjustments for all five kVp breakpoints are now made by only adjusting the AEC reference at each of those breakpoints.
- Repeat the above steps for wall bucky AEC calibration ***except*** no generator AEC adjustments are made for wall bucky AEC calibration. The AEC gain setting and AEC reference settings made during table bucky calibration are used for the wall bucky AEC chamber also. The wall bucky AEC chamber gain settings must therefore be set to match the gain of the table bucky AEC chamber.

Step	Action
	SETUP FOR AEC CALIBRATION
1.	Confirm that the table bucky AEC chamber is connected to the correct input on the AEC board per chapter 2. Ensure that the AEC chamber is properly calibrated and the fields are balanced before continuing.
2.	Align the tube stand and table Bucky such that the central ray is centered relative to the image receptor.
3.	Open up the collimator just enough to expose all fields of the AEC pickup. Ensure that the central ray remains centered relative to the image receptor.
4.	Place 15 cm thickness of water between the collimator and the image receptor. The water must be in a flat, X-ray transparent container, sufficiently large to ensure that the X-ray field is fully blocked as noted in 3.7.2.
5.	Place the generator into the programming mode. Refer to section 3.3.0.
6.	Select **AEC ADJUSTMENT** from the level 2 utilities. Refer to 3.5.0. Select the table bucky receptor.

3.7.4 AEC Calibration (Table Bucky) Cont

Step	Action
	80 KVP KNEE BREAKPOINT CALIBRATION
7.	Select the 80 kVp knee breakpoint #3 for F/S 1.
8.	In each step following, where an exposure is made to verify the density, set the **B/U mAs** sufficiently high that the AEC exposure is not terminated by the backup timer.
9.	Press **UP** or **DOWN** to set the **AEC REF** to 325 (the range is 0 to 1023).
10.	Load a test cassette with fresh film and install it in the image receptor. Use a film / screen combination corresponding to F/S 1.
11.	Select **GAIN ADJ.** Select F/S 1 (note again that F/S 1 is a mnemonic used in this procedure for the first film / screen being calibrated). Set F/S 1 to an initial gain value (n) as per table 3-6 using the **GAIN** ↑ or ↓ buttons. Table 3-6 shows recommended starting gain values for 100, 400 and 800 speed film / screens.
12.	Press the menu button [**5**] to return to the AEC breakpoint calibration screen.
13.	Make an X-ray exposure. Then develop the film and measure the optical density.
14.	If the measured O.D. is not within 5% of the desired value, readjust the AEC gain (as per step 11) to increase or decrease the density. Increasing the gain value will decrease the density, decreasing the gain value will increase the density.
15.	Load the test cassette in step 10 with fresh film and install it in the image receptor. Make an X-ray exposure, then develop the film and measure the optical density.
16.	Repeat steps 14 and 15 until the desired O.D. is achieved at the kVp knee breakpoint.
17.	Once the desired film density is achieved, record the post mAs, AEC gain adjustment calibration number, AEC reference number, and O.D. in a copy of table 3-7 for the 80 kVp knee breakpoint.
	55 KVP BREAKPOINT CALIBRATION
18.	Replace the water in step 4 with 10 cm thickness of water. As before, ensure that the absorber fully blocks the X-ray field.
19.	Select the 55 kVp breakpoint for F/S 1.
20.	Load the test cassette in step 10 with fresh film and install it in the image receptor. Make an X-ray exposure, then develop the film and measure the optical density.
21.	If the measured O.D. is not within 5% of the desired value, adjust the **AEC REF** value for the 55 kVp breakpoint. **DO NOT READJUST THE *GAIN ADJ* SETTING.** Increasing the AEC REF value will increase the density, decreasing the AEC REF value will decrease the density.
22.	Repeat steps 20 and 21 until the desired O.D. is achieved at the 55 kVp breakpoint.
23.	Record the post mAs, AEC reference number, and O.D. in a copy of table 3-7 for the 55 kVp breakpoint.
	65 KVP BREAKPOINT CALIBRATION
24.	Select the 65 kVp breakpoint for F/S 1.
25.	Load the test cassette in step 10 with fresh film and install it in the image receptor. Make an X-ray exposure, then develop the film and measure the optical density.
26.	If the measured O.D. is not within 5% of the desired value, adjust the **AEC REF** value for the 65 kVp breakpoint. **DO NOT READJUST THE *GAIN ADJ* SETTING.**
27.	Repeat steps 25 and 26 until the desired O.D. is achieved at the 65 kVp breakpoint.
28.	Record the post mAs, AEC reference number, and O.D. in a copy of table 3-7 for the 65 kVp breakpoint.

3.7.4 AEC Calibration (Table Bucky) Cont

Step	Action
	100 KVP BREAKPOINT CALIBRATION
29.	Replace the water in step 18 with 20 cm thickness of water. As before, ensure that the absorber fully blocks the X-ray field.
30.	Select the 100 kVp breakpoint for F/S 1.
31.	Load the test cassette in step 10 with fresh film and install it in the image receptor. Make an X-ray exposure, then develop the film and measure the optical density.
32.	If the measured O.D. is not within 5% of the desired value, adjust the **AEC REF** value for the 100 kVp breakpoint. **DO NOT READJUST THE *GAIN AD* SETTING.**
33.	Repeat steps 31 and 32 until the desired OD is achieved at the 100 kVp breakpoint.
34.	Record the post mAs, AEC reference number, and OD in a copy of table 3-7 for the 100 kVp breakpoint.
	125 kVp BREAKPOINT CALIBRATION
35.	Select the 125 kVp breakpoint for F/S 1.
36.	Load the test cassette in step 10 with fresh film and install it in the image receptor. Make an X-ray exposure, then develop the film and measure the optical density.
37.	If the measured OD is not within 5% of the desired value, adjust the **AEC REF** value for the 125 kVp breakpoint. **DO NOT READJUST THE *GAIN ADJ* SETTING.**
38.	Repeat steps 36 and 37 until the desired O.D. is achieved at the 125 kVp breakpoint.
39.	Record the post mAs, AEC reference number, and O.D. in a copy of table 3-7 for the 125 kVp breakpoint.

Step	Action
	FILM / SCREEN 2 BREAKPOINT CALIBRATION
40.	Perform F/S 2 calibration only if it is intended to use this film / screen combination. If this is NOT being used, ensure that this film / screen combination is not used in any anatomical displays.
41.	Repeat steps 7 to 39 as described for film / screen 1 ***except*** use a test cassette and film to match F/S 2. Be sure that the correct AEC breakpoints are being calibrated, screens 6-10 in the AEC ADJUSTMENT menus calibrate film / screen 2. These screens are accessed by completing the 125 kVp breakpoint for F/S 1, and pressing → as described earlier.

Step	Action
	FILM / SCREEN 3 BREAKPOINT CALIBRATION
42.	Perform F/S 3 calibration only if it is intended to use this film / screen combination. If this is NOT being used, ensure that this film / screen combination is not used in any anatomical displays.
43.	Repeat steps 7 to 39 as described for film screen 1 ***except*** use a test cassette and film to match F/S 3. Be sure that the correct AEC breakpoints are being calibrated, screens 11-15 in the AEC ADJUSTMENT menus calibrate film / screen 3. These screens are accessed by completing the 125 kVp breakpoint for F/S 2, and pressing → as described earlier.

3.7.4 AEC Calibration (Table Bucky) Cont

FILM / SCREEN	INITIAL *GAIN ADJ* VALUE (n)
100	150
400	236
800	244

Table 3-6: Initial gain value vs film / screen speed

The relative AEC voltage gain is expressed by:

$$\text{AEC VOLTAGE GAIN} = \frac{n}{255-n}$$

Where n ranges from 0 to 254. This means that for low values of n, there is very little slope to the AEC gain curve. Therefore, n needs to change substantially to effect significant gain changes. For high values of n, the AEC gain curve is quite steep, as a result minor changes in n will have a significant effect on AEC gain.

3.7.4 Table 3-7: Breakpoint Worksheet

Record the final results in a copy of the table below. The final results are those obtained AFTER films have been developed to verify the correct O.D. at each breakpoint.

TABLE BUCKY

FILM SCREEN 1	**SPEED =**	**AEC GAIN ADJ CAL # _____ @ kVp _____**	
#3 BK. POINT = 80 kVp	Post mAs =	AEC REF NO. =	O.D. =
#1 BK. POINT = 55 kV	Post mAs =	AEC REF NO. =	O.D. =
#2 BK. POINT = 65 kV	Post mAs =	AEC REF NO. =	O.D. =
#4 BK. POINT = 100 kV	Post mAs =	AEC REF NO. =	O.D. =
#5 BK. POINT = 125 kV	Post mAs =	AEC REF NO. =	O.D. =

FILM SCREEN 2	**SPEED =**	**AEC GAIN ADJ CAL # _____ @ kVp _____**	
#3 BK. POINT = 80 kVp	Post mAs =	AEC REF NO. =	O.D. =
#1 BK. POINT = 55 kV	Post mAs =	AEC REF NO. =	O.D. =
#2 BK. POINT = 65 kV	Post mAs =	AEC REF NO. =	O.D. =
#4 BK. POINT = 100 kV	Post mAs =	AEC REF NO. =	O.D. =
#5 BK. POINT = 125 kV	Post mAs =	AEC REF NO. =	O.D. =

FILM SCREEN 3	**SPEED =**	**AEC GAIN ADJ CAL # _____ @ kVp _____**	
#3 BK. POINT = 80 kVp	Post mAs =	AEC REF NO. =	O.D. =
#1 BK. POINT = 55 kV	Post mAs =	AEC REF NO. =	O.D. =
#2 BK. POINT = 65 kV	Post mAs =	AEC REF NO. =	O.D. =
#4 BK. POINT = 100 kV	Post mAs =	AEC REF NO. =	O.D. =
#5 BK. POINT = 125 kV	Post mAs =	AEC REF NO. =	O.D. =

WALL BUCKY

FILM SCREEN 1	**SPEED =**	
#3 BK. POINT = 80 kVp	Post mAs =	O.D. =
#1 BK. POINT = 55 kV	Post mAs =	O.D. =
#2 BK. POINT = 65 kV	Post mAs =	O.D. =
#4 BK. POINT = 100 kV	Post mAs =	O.D. =
#5 BK. POINT = 125 kV	Post mAs =	O.D. =

FILM SCREEN 2	**SPEED =**	
#3 BK. POINT = 80 kVp	Post mAs =	O.D. =
#1 BK. POINT = 55 kV	Post mAs =	O.D. =
#2 BK. POINT = 65 kV	Post mAs =	O.D. =
#4 BK. POINT = 100 kV	Post mAs =	O.D. =
#5 BK. POINT = 125 kV	Post mAs =	O.D. =

FILM SCREEN 3	**SPEED =**	
#3 BK. POINT = 80 kVp	Post mAs =	O.D. =
#1 BK. POINT = 55 kV	Post mAs =	O.D. =
#2 BK. POINT = 65 kV	Post mAs =	O.D. =
#4 BK. POINT = 100 kV	Post mAs =	O.D. =
#5 BK. POINT = 125 kV	Post mAs =	O.D. =

3.7.5 AEC Calibration (Wall Bucky)

The AEC calibration curves that were established in 3.7.4 are used for the wall Bucky as well as the table Bucky. If the calibration on both AEC chambers is similar, the optical density measurements for the wall Bucky should be similar to the table Bucky. If there are significant differences in O.D. between the table Bucky measurements and the wall Bucky measurements under similar conditions, troubleshooting of equipment external to the generator will need to be undertaken.

Step	Action
	SETUP FOR AEC CALIBRATION
1.	Confirm that the wall bucky AEC chamber is connected to the correct input on the AEC board per chapter 2. Ensure that the AEC chamber is properly calibrated and the fields are balanced before continuing.
2.	Repeat steps 2 to 6 of 3.7.4, ***EXCEPT*** align the tube stand and wall Bucky in step 2, and select the wall Bucky receptor in step 6.
	80 KVP KNEE BREAKPOINT VERIFICATION
3.	Select the 80 kVp knee breakpoint #3 for F/S 1. **DO NOT ADJUST THE AEC REF VALUE, USE THE SETTING THAT WAS ESTABLISHED FOR TABLE BUCKY CALIBRATION.**
4.	Load a test cassette with fresh film and install it in the image receptor. Use a film / screen combination corresponding to F/S 1.
5.	Make an X-ray exposure. Then develop the film and measure the optical density.
6.	If the measured O.D. is not within 5% of the value previously recorded in table 3-7, adjust the AEC chamber gain per the manufacturers instructions to increase or decrease the density.
7.	Repeat steps 5 and 6 until the desired O.D. is achieved at the 80 kVp knee breakpoint.
8.	Once the desired film density is achieved, record the post mAs, and O.D. in a copy of table 3-7 for the 80 kVp knee breakpoint.
	55 KVP BREAKPOINT CALIBRATION
9.	Replace the 15 cm of water with 10 cm thickness of water. As before, ensure that the absorber fully blocks the X-ray field.
10.	Select the 55 kVp breakpoint for F/S 1. **DO NOT ADJUST THE AEC REF VALUE, USE THE SETTING THAT WAS ESTABLISHED FOR TABLE BUCKY CALIBRATION.**
11.	Load the test cassette in step 4 with fresh film and install it in the image receptor. Make an X-ray exposure, then develop the film and measure the optical density.
12.	Verify that the O.D. is within 5 % of the value previously recorded in table 3-7. If this is not so, it indicates that the two AEC chambers are not tracking and troubleshooting must be done at the system level.
13.	If the desired O.D. is achieved, record the post mAs, and O.D. in a copy of table 3-7 for the 55 kVp knee breakpoint.
	65 KVP BREAKPOINT CALIBRATION
14.	Select the 65 kVp breakpoint for F/S 1. **DO NOT ADJUST THE AEC REF VALUE, USE THE SETTING THAT WAS ESTABLISHED FOR TABLE BUCKY CALIBRATION.**
15.	Load the test cassette in step 4 with fresh film and install it in the image receptor. Make an X-ray exposure, then develop the film and measure the optical density.
16.	Verify that the O.D. is within 5 % of the value previously recorded in table 3-7.
17.	If the desired O.D. is achieved, record the post mAs, and O.D. in a copy of table 3-7 for the 65 kVp knee breakpoint.

3.7.5 AEC Calibration (Wall Bucky) Cont

	100 KVP BREAKPOINT CALIBRATION
18.	Replace the 10 cm of water with 20 cm thickness of water. As before, ensure that the absorber fully blocks the X-ray field.
19.	Select the 100 kVp breakpoint for F/S 1. **DO NOT ADJUST THE AEC REF VALUE, USE THE SETTING THAT WAS ESTABLISHED FOR TABLE BUCKY CALIBRATION.**
20.	Load the test cassette in step 4 with fresh film and install it in the image receptor. Make an X-ray exposure, then develop the film and measure the optical density.
21.	Verify that the O.D. is within 5 % of the value previously recorded in table 3-7.
22	If the desired O.D. is achieved, record the post mAs, and O.D. in a copy of table 3-7 for the 100 kVp knee breakpoint.
	125 KVP BREAKPOINT CALIBRATION
23.	Select the 125 kVp breakpoint for F/S 1. **DO NOT ADJUST THE AEC REF VALUE, USE THE SETTING THAT WAS ESTABLISHED FOR TABLE BUCKY CALIBRATION.**
24.	Load the test cassette in step 4 with fresh film and install it in the image receptor. Make an X-ray exposure, then develop the film and measure the optical density.
25.	Verify that the O.D. is within 5 % of the value previously recorded in table 3-7.
26.	If the desired O.D. is achieved, record the post mAs, and O.D. in a copy of table 3-7 for the 125 kVp knee breakpoint.

Step	Action
	FILM / SCREEN 2 BREAKPOINT CALIBRATION
27.	Verify F/S 2 calibration only if it is intended to use this film / screen combination with the wall Bucky.
28.	Repeat steps 3 to 26 as described for film / screen 1 ***except*** use a test cassette and film to match F/S 2. Be sure that the correct AEC breakpoints are being verified.

Step	Action
	FILM / SCREEN 3 BREAKPOINT CALIBRATION
29.	Verify F/S 3 calibration only if it is intended to use this film / screen combination with the wall Bucky.
30.	Repeat steps 3 to 26 as described for film screen 1 ***except*** use a test cassette and film to match F/S 3. Be sure that the correct AEC breakpoints are being verified.

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CHAPTER 4

ACCEPTANCE TESTING

CONTENTS:

4.1.0 INTRODUCTION 4-2
4.2.0 REQUIRED TEST EQUIPMENT FOR GENERATOR VERIFICATION. 4-3
4.3.0 CONSOLE OVERVIEW 4-3
4.4.0 ACCEPTANCE TESTS (BASIC FUNCTIONS) 4-4
4.4.1 Console Functional Tests 4-4
4.4.2 Low Speed Starter Tests 4-6
4.4.3 Generator kVp, mAs Tests 4-6
4.5.0 AEC VERIFICATION 4-7
4.6.0 ACCEPTANCE TESTS (REPRODUCIBILITY, LINEARITY AND HVL) 4-8

4.1.0 INTRODUCTION

This section details acceptance testing which verifies that the generator is performing within its limits. It is recommended that this be done after the unit is installed, as prescribed in the maintenance schedule in Chapter 6, or when components are replaced which may affect the calibration or X-ray output. Examples of such components are the X-ray tube, HT tank, power supply control board, filament board, CPU board, and the AEC board.

Calibration procedures will be supplied with replacement parts in those cases where recalibration is necessary after replacement of that assembly.

WARNING: ***USE EXTREME CARE IN MEASURING HIGH VOLTAGES. ACCIDENTAL CONTACT MAY CAUSE SERIOUS INJURY OR DEATH.***

MAINS VOLTAGE WILL BE PRESENT INSIDE THE GENERATOR CABINET, EVEN WITH THE CONSOLE SWITCHED OFF. THIS VOLTAGE IS EXTREMELY DANGEROUS, USE EXTREME CAUTION.

THE DC BUS CAPACITORS, LOCATED ON THE DC BUS ASSEMBLY, PRESENT A HAZARD FOR A MINIMUM OF 5 MINUTES AFTER THE GENERATOR HAS BEEN SWITCHED OFF. CHECK THAT THESE CAPACITORS ARE DISCHARGED BEFORE TOUCHING ANY PARTS IN THE GENERATOR.

WARNING: ***THE PROCEDURES IN THIS CHAPTER REQUIRE THE PRODUCTION OF X-RAYS. TAKE ALL APPROPRIATE SAFETY PRECAUTIONS TO PROTECT PERSONNEL FROM X-RAY RADIATION.***

WARNING: ***ALWAYS ENSURE THAT THE EQUIPMENT UNDER TEST AND ALL ASSOCIATED TEST EQUIPMENT IS PROPERLY GROUNDED***

ENSURE THAT THE HIGH VOLTAGE CABLES ARE INTACT / UNDAMAGED AND PROPERLY CONNECTED BEFORE ATTEMPTING EXPOSURES

ENSURE THAT THE FOLLOWING ITEMS ARE COMPLETED PRIOR TO PERFORMING THE ACCEPTANCE TESTING:

- **The tube auto calibration has been done as per Chapter 3 of this manual.**
- **The programming has been completed as per Chapter 3.**
- **If the installation has AEC; verify that AEC calibration has been completed as per Chapter 3.**
- **Acceptance testing shall only be started after the installation is complete i.e. generator installed as per Chapter 2.**

4.2.0 REQUIRED TEST EQUIPMENT FOR GENERATOR VERIFICATION.

- kV measuring device such as a Dynalyzer (or equivalent), or a non-invasive kVp meter.
- Two channel storage oscilloscope.
- mA / mAs meter.
- Radiation meter 0-1000 mR and 1-15 R/min.
- Lead diaphragm or equivalent to collimate the beam.
- General purpose DVM.
- Strobe or reed tachometer.
- Current probe 0 to 20 amps AC. This is to be used with the oscilloscope to view the stator current waveform.
- A set of HVL filters (see attached supplement).
- Calculator.

4.3.0 CONSOLE OVERVIEW

Figure 4-1 shows the designations of the membrane switches as referenced in this procedure.

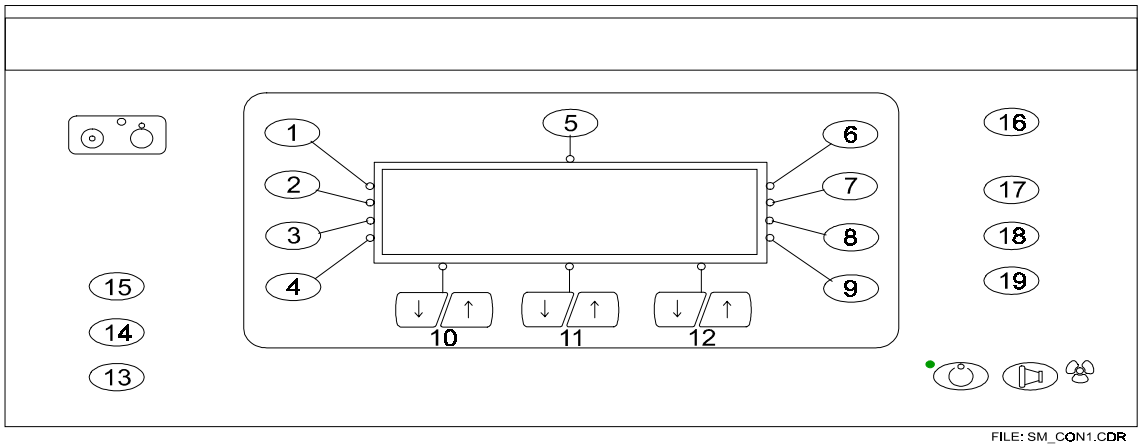

Figure 4-1: Console switch designations

4.4.0 ACCEPTANCE TESTS (BASIC FUNCTIONS)

4.4.1 Console Functional Tests

Refer to figure 4-1 for the button designations [**1**] to [**19**]

Step	Action	Result	Check
1.	Press power ON then power OFF button on the console.	Generator switches on and off.	
2.	Press power ON again to switch unit on.	The PREP and X-RAY LEDS should briefly light. The green LED adjacent to the power ON switch should light.	
3.	Press **OK** and / or **RESET**, if required, to proceed to the main screen shown in figure 4-2. This may be displayed if an error is present when the generator is powered up.		
4.	From the main APR menu, press APR button [**1**].	Verify that the available views within that anatomical section are displayed. Refer to figure 4-2 and 4-3.	
5.	Press the menu button [**5**] to return to the main menu.	The main menu screen should be displayed.	
6.	Repeat steps 4 and 5 for APR buttons [**2**] to [**4**] and [**6**] to [**9**].	The display should be per steps 4 and 5.	
7.	Select a technique within an anatomical view. See figure 4-4.	The display should be per figure 4-4.	
8.	Change technique parameters (press the ↑ and ↓ buttons [**10**], [**11**], and [**12**]).	Verify that each of the selected techniques change as appropriate.	
9.	Press each of the receptor buttons [**13**] to [**15**].	Verify that the desired receptor is selected. Receptors not enabled in programming cannot be selected, refer to RECEPTOR CONF. in Chapter 3.	
10.	Select the TABLE or WALL bucky. Press AEC button [**16**].	Verify that AEC is selected / deselected by pressing this button. AEC must be enabled in programming in order to select AEC, refer to RECEPTOR CONF. and CONFIGURATION in Chapter 3.	
11.	Press each of field select buttons [**17**], [**18**], and [**19**] with AEC enabled.	Verify that each field is selected in turn. ION CHAMBER AEC must be selected in order to activate all three fields, refer to CONFIGURATION in Chapter 3.	
12.	Press the PREP button.	The green LED adjacent to the PREP button should light.	
13.	Press the X-RAY button.	The X-RAY warning light adjacent to the X-RAY button should light,	
14.	Press the power OFF button on the console.	Generator switches off.	

4.4.1 Console Functional Tests (Cont)

Depending on generator model, the main menu on your console may show anatomical sections different from those shown below.

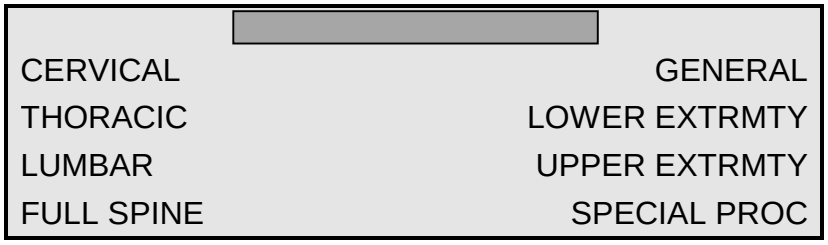

Figure 4-2: Main console menu

Depending on generator model and selected anatomical section, the anatomical views may differ from those shown below.

Figure 4-3: Typical anatomical views

The screen shown below is a typical techniques screen in non-AEC mode.

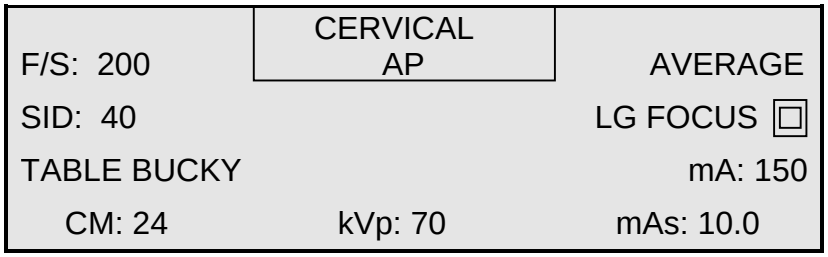

Figure 4-4: Typical techniques screen

> ***NOTE:*** ***THE SCREENS SHOWN ABOVE ARE EXAMPLES ONLY, ACTUAL SCREENS AND TECHNIQUES MAY VARY IN DETAIL.***

4.4.2 Low Speed Starter Tests

Step	Action	Result	Check
1.	Connect a current probe to the common lead of the X-ray tube stator. Switch ON the console. Press and hold the PREP button.	A 60 Hz waveform dropping to less than half amplitude after prep complete.	
2.	Measure the rotor boost time.	Should be approximately 1.5 sec.	
3.	Use a strobe or reed tachometer and verify that the tube reaches operating speed at end of boost.	Speed ≥ 3300 RPM.	
4.	Switch OFF the console.	N/A	

4.4.3 Generator kVp, mAs Tests

NOTE: ***A DYNALYZER IS NOT RECOMMENDED FOR MA MEASUREMENTS WITH THIS X-RAY GENERATOR. BANDWIDTH LIMITATIONS OF THE DYNALYZER WILL RESULT IN INACCURATE MA MEASUREMENTS AT MA VALUES LESS THAN APPROXIMATELY 100 MA. MA MEASUREMENTS SHOULD BE MADE WITH AN MA / MAS METER CONNECTED TO THE MA TEST JACKS ON THE HT TANK. EXPOSURE TIMES MUST BE GREATER THAN 100 MS TO ENSURE ACCURATE MEASUREMENTS.***

WARNING : ***TAKE ALL APPROPRIATE PRECAUTIONS WHEN CONNECTING THE MA / MAS METER TO THE HT TANK. ENSURE MAINS POWER IS SWITCHED OFF AND ALL CAPACITORS ARE DISCHARGED BEFORE CONNECTING THE METER. USE THE SAME PRECAUTIONS WHEN DISCONNECTING THE METER. THE MA SHORTING LINK MUST BE IN PLACE ON THE HT TANK AT ALL TIMES EXCEPT WHEN AN APPROVED MA / MAS METER IS CONNECTED.***

Step	Action	Result	Check
1.	Set up the kVp measuring device to measure kVp as per the manufacturers instructions. Connect the output of the kVp measuring device to channel 1 of the oscilloscope.	N/A	
2.	Set up an mA / mAs meter to measure X-ray tube current by temporarily open-circuiting the mA measuring link E17-E18 on the HT tank. Connect the mA / mAS meter to these terminals, following the device manufacturers instructions. Connect the output of the mA / mAS meter to channel 2 of the oscilloscope.	N/A	

4.4.3 Generator kVp, mAs Tests (Cont)

NOTE: ***TEST EQUIPMENT TOLERANCES MUST BE ALLOWED FOR IN THE MEASUREMENTS IN THE FOLLOWING SECTIONS. LIMITS STATED ARE THE MAXIMUM ALLOWED LIMITS, INCLUDING EQUIPMENT TOLERANCES AND MEASUREMENT ERROR.***

DISREGARD "CABLE CHARGE" SPIKES AT THE BEGINNING OF THE MA WAVEFORM.

IF HIGH KV EXPOSURES ARE NOT ALLOWED IN THE FOLLOWING STEPS, CHECK THE MAXIMUM KV SETTING THAT HAS BEEN PROGRAMMED. REFER TO "*CONFIGURATION*" IN CHAPTER 3.

Step	Action	Result	Check
	If the following mAs steps are not available, the mAs step size may need to be set, refer to MAS STEP SIZE in Chapter 3.		
3.	Switch ON the generator and after initialization select the following technique: Select the NON BUCKY receptor [**14**] Select kVp = 100, mA = 100, mAs = 10.	N/A	
4.	Make an exposure and verify the following results. If calculating mAs from mA and time measurements, then measure time at 75% of the peak kVp waveform.	kVp = 100 ± 5.0 kV. mAs = 10 ± 1.5 mAs.	
5.	Repeat steps 3 and 4 but set the values to kVp = 65, mA = 200, mAs = 20.	kVp = 65 KV ± 3.25 kV. mAs = 20 ± 2.5 mAs.	
6.	Repeat steps 3 and 4 but set the values to kVp = 120, mA = 200, mAs = 20.	kVp = 120 KV ± 6.0 kV. mAs = 20 ± 2.5 mAs.	
7.	Select 75 kVp, 150 mA, large focus. Select the mAs values shown below. A: 1.2 mAs. B: 8.0 mAs. C: 26.0 mAs. D: 63.0 mAs.	 A: 1.2 mAs ± 0.62 mAs. B: 8 mAs ± 1.3 mAs. C: 26 mAs ± 3.1 mAs. D: 63 mAs ± 6.8 mAs.	
8.	Select 100 mA, 5 mAs, small focus. Select the kVp values shown below. A: 50 kVp. B: 60 kVp. C: 80 kVp. D: 120 kVp E: 130 kVp (150 kV generators only).	 A: 50 kVp ± 2.5 kV. B: 60 kVp ± 3 kV. C: 80 kVp ± 4 kV. D: 120 kVp ± 4.8 kV. E: 130 kVp ± 5.2 kV.	

4.5.0 AEC VERIFICATION

This section applies only to generators with AEC.

- Review Chapter 3: AEC Adjustment.
- Follow the appropriate steps in Chapter 3 to verify the AEC calibration.

4.6.0 ACCEPTANCE TESTS (REPRODUCIBILITY, LINEARITY AND HVL)

The procedure for performing reproducibility, linearity and HVL testing is contained in a separate document, part number 740917-00 which immediately follows this page.

SUPPLEMENT

REPRODUCIBILTY, LINEARITY, & HVL TESTING

CONTENTS:

1.0 INTRODUCTION 2
2.0 EQUIPMENT SETUP.....3
3.0 REPRODUCIBILITY 3
4.0 LINEARITY.....7
5.0 H.V.L. EVALUATION 9

1.0 INTRODUCTION

This supplement describes reproducibility, linearity, and half - value layer (HVL) tests which may be used to verify performance of medical X-ray generators.

NOTE:	***THIS SUPPLEMENT DETAILS TYPICAL REPRODUCIBILITY, LINEARITY, AND HVL TESTS. LOCAL REGULATIONS SHOULD ALWAYS BE CONSULTED PRIOR TO PERFORMING THESE TESTS, AS DETAILS MAY VARY IN SOME JURISDICTIONS, OR ADDITIONAL TESTS MAY NEED TO BE PERFORMED.***

WARNING:	***SOME EXPOSURES IN THIS SECTION MUST BE TAKEN AT THE MAXIMUM GENERATOR KVP. THE X-RAY TUBE MUST BE KNOWN TO BE CAPABLE OF OPERATION AT THAT KVP VALUE, AND THE TUBE SHOULD FIRST BE SEASONED TO ENSURE THAT OPERATION AT HIGH KVP VALUES WILL NOT BE PROBLEMATIC.***

2.0 EQUIPMENT SETUP

1. Place the radiation probe above the table approximately 25 cm (10”). Select an SID of approximately 100 cm (40”).

2. Place a lead diaphragm over the detector and adjust its height so that the X-ray beam covers the detector but does not over radiate the sides of the ‘R’ probe. Refer to figure 1.

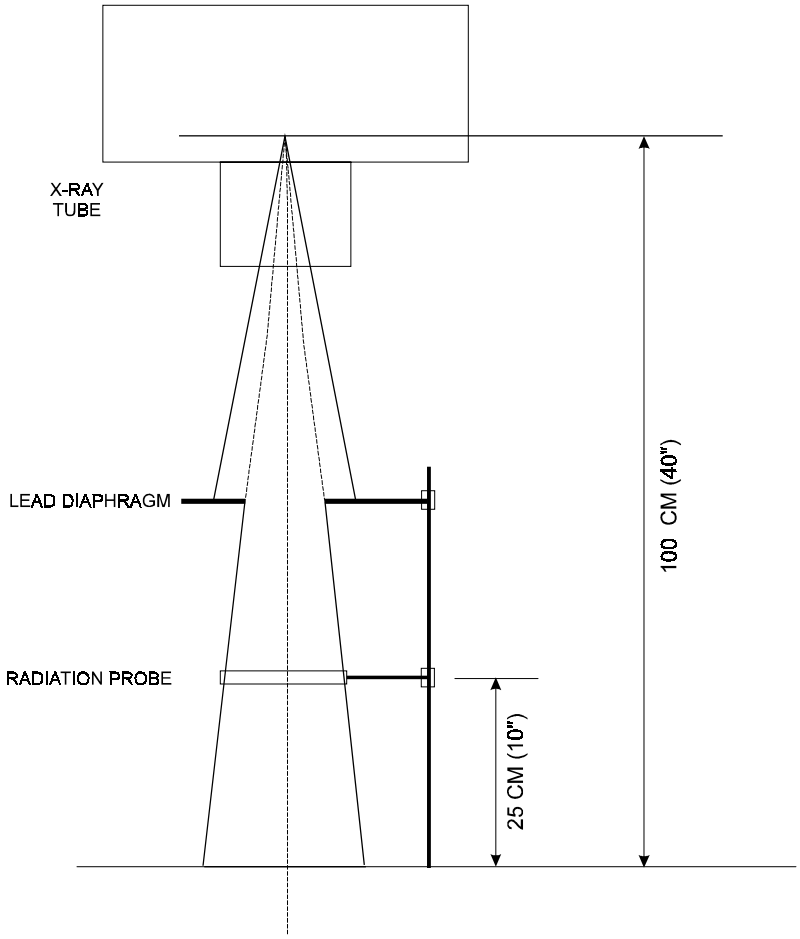

Figure 1: mR measurement setup

3.0 REPRODUCIBILITY

Calculate reproducibility as follows:

1. Using kV and mA/ms or mAs values per tables 1 to 4, make a series of 5 exposures.

2. Record each of the measured mR values in the appropriate table. Refer to step 3 before beginning step 2.

3. Record the preselected mAs for each series of exposures in the header of each table. For 3 point generators, this is the calculated mAs value where mAs = mA X time in seconds (example for 160 mA and 125 ms, mAs = 160 X 0.125 = 20 mAs).

3.0 REPRODUCIBILITY (Cont)

4. Calculate and record the average dose $\overline{mR}$.

5. Calculate the difference mR - $\overline{mR}$ for each exposure.

6. Square each difference from the previous step.

7. Calculate the sum of the differences squared.

8. Calculate the standard deviation (S) by using the formula.

$$S = \sqrt{\frac{\text{SUM OF DIFFERENCES}^2}{\text{N-1 SAMPLES}}}$$

9. Calculate reproducibility by dividing S by $\overline{mR}$.

10. Table 5 shows example reproducibility calculations.

11. If linearity is to be measured, it is suggested that dose measurements be taken at this time for entry into tables 6 and 7. Refer to 4.0 LINEARITY for details.

IN TABLES 1 TO 4, 3 POINT MEANS THAT FOR GENERATORS WHERE KV, MA, AND TIME SELECTION IS AVAILABLE, THE KV, MA AND MS VALUES SHOWN SHOULD BE USED. FOR GENERATORS WHERE 2 POINT OPERATION ONLY IS AVAILABLE, THE KV AND MAS VALUES SHOWN SHOULD BE USED.

3 point = Minimum kV, maximum mA, 100 ms.
2 point = Minimum kV, maximum mAs. mAs = _____

EXP No.	DOSE (mR)	DIFFERENCE	DIFFERENCE^2
1			
2			
3			
4			
5			
	$\overline{mR}$ = _____	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = _____

Calculate standard deviation (S) using formula at beginning of this section: S = _____

Calculate reproducibility = $\frac{S}{\overline{mR}}$ = _____ (not to exceed 0.045)

Table 1: Reproducibility

3.0 REPRODUCIBILITY (Cont)

3 point = Maximum kV, minimum mA, 100 ms. 2 point = Maximum kV, minimum mAs. mAs = _____			
EXP No.	**DOSE (mR)**	**DIFFERENCE**	**DIFFERENCE^2**
1			
2			
3			
4			
5			
	$\overline{mR}$ = _____	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = _____
Calculate standard deviation (S) using formula at beginning of this section: S = _____ Calculate reproducibility = $\frac{S}{\overline{mR}}$ = _____ (not to exceed 0.045)			

Table 2: Reproducibility

3 point = 50% of maximum kV, 250 ms, mA to give 100 - 500 μR (1 - 5 μGy) dose. 2 point = 50% of maximum kV, mAs to give 100 - 500 μR (1 - 5 μGy) dose. mAs = _____			
EXP No.	**DOSE (mR)**	**DIFFERENCE**	**DIFFERENCE^2**
1			
2			
3			
4			
5			
	$\overline{mR}$ = _____	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = _____
Calculate standard deviation (S) using formula at beginning of this section: S = _____ Calculate reproducibility = $\frac{S}{\overline{mR}}$ = _____ (not to exceed 0.045)			

Table 3: Reproducibility

3.0 REPRODUCIBILITY (Cont)

3 point = 80% of maximum kV, 250 ms, mA to give 100 - 500 μR (1 - 5 μGy) dose. 2 point = 80% of maximum kV, mAs to give 100 - 500 μR (1 - 5 μGy) dose. MAS = _____			
EXP No.	**DOSE (mR)**	**DIFFERENCE**	**DIFFERENCE^2**
1			
2			
3			
4			
5			
	$\overline{mR}$ = _____	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = _____
Calculate standard deviation (S) using formula at beginning of this section: S = _____ Calculate reproducibility = $\frac{S}{\overline{mR}}$ = _____ (not to exceed 0.045)			

Table 4: Reproducibility

EXAMPLE mAs = 20			
EXP No.	**DOSE (mR)**	**DIFFERENCE**	**DIFFERENCE^2**
1	249.0	4.4	19.36
2	245.0	0.4	0.16
3	244.0	0.6	0.36
4	242.0	2.6	6.76
5	243.0	1.6	2.56
	$\overline{mR}$ = 244.6	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = 29.2
Calculate standard deviation (s) using formula at beginning of this section: S = 2.70 Calculate reproducibility = $\frac{S}{\overline{mR}}$ = 0.011 (not to exceed 0.045)			

Table 5: Reproducibility

4.0 LINEARITY

1. Record two additional series of dose measurements for entry into tables 6 and 7:
   - For table 6, use settings per table 3 ***EXCEPT*** use an mA (or mAs) value adjacent to the mA (or mAs) setting used in table 3.
   - For table 7, use settings per table 4 ***EXCEPT*** use an mA (or mAs) value adjacent to the mA (or mAs) setting used in table 4.
   - Record the mAs in the header of tables 6 and 7 as per 3.0 step 3.

1. Calculate and record the average dose $\overline{mR}$ for table 6 and 7.

2. Record the preselected mAs and the average dose values taken from tables 3 and 4, and from tables 6 and 7, at the top of the next page.

3. Using the appropriate mAs and $\overline{mR}$ values, calculate X_3, X_4, X_6, and X_7 in tables 8 and 9.

4. Calculate the coefficient of linearity, L, as per tables 8 and 9.

mAs = _____	
EXP No.	**DOSE (mR)**
1	
2	
3	
4	
5	
	$\overline{mR}$ = _____

Table 6: Linearity

mAs = _____	
EXP No.	**DOSE (mR)**
1	
2	
3	
4	
5	
	$\overline{mR}$ = _____

Table 7: Linearity

4.0 LINEARITY (Cont)

Record the mAs and $\overline{mR}$ values taken from tables 3, 4, 6, and 7 below.

Table 3	mAs_3 = _____	$\overline{mR}_3$ = _____
Table 4	mAs_4 = _____	$\overline{mR}_4$ = _____
Table 6	mAs_6 = _____	$\overline{mR}_6$ = _____
Table 7	mAs_7 = _____	$\overline{mR}_7$ = _____

$$X_3 = \frac{\overline{mR}_3}{mAs_3} = \_\_\_\_\_$$

$$X_6 = \frac{\overline{mR}_6}{mAs_6} = \_\_\_\_\_$$

$$L = \frac{X_3 - X_6}{X_3 + X_6} = \_\_\_\_\_ \text{ (not to exceed 0.095)}$$

In the numerator of the above equation, use the absolute value of $X_3 - X_6$ (disregard the minus sign).

Table 8: Linearity

$$X_4 = \frac{\overline{mR}_4}{mAs_4} = \_\_\_\_\_$$

$$X_7 = \frac{\overline{mR}_7}{mAs_7} = \_\_\_\_\_$$

$$L = \frac{X_4 - X_7}{X_4 + X_7} = \_\_\_\_\_ \text{ (not to exceed 0.095)}$$

In the numerator of the above equation, use the absolute value of $X_4 - X_7$ (disregard the minus sign).

Table 9: Linearity

5.0 H.V.L. EVALUATION

1. Be sure the X-ray source assembly (X-ray tube and beam limiting device) is fully assembled and functional.

2. Use the test setup as per figure 1.

3. Set the generator as follows: 3 point generators, 80 kV, 200 mA, 50 ms, large focus. For 2 point generators use 80 kV, 200 mA if this can be set, and 10 mAs.

4. Take a series of three exposures and record the mR values in table 10. Calculate and record the average of the three exposures.

5. Place 2 mm of Al on top of the lead diaphragm (total of 2 mm added), repeat the exposure and record the mR value in table 10.

6. Place an additional 1 mm of Al on top of the lead diaphragm (total of 3 mm added), repeat the exposure; and record the mR value in table 10.

7. Place an additional 3 mm of Al on top of the lead diaphragm (total of 6 mm added), repeat the exposure; and record the mR value in table 10.

8. The relative transmission for the average of the three mR values where no Al was added is assigned a value of 1.00. Using that base, assign relative transmission values to the remaining mR values. For example, if the average mR value was 247 and has a relative transmission factor of 1.00, then 162 mR will have a relative transmission of 162 / 247 = 0.66.

9. Plot the relative transmission values in figure 1. This should produce a straight line on the graph since the X-axis is logarithmic.

10. Interpolate to determine the HVL. The Al thickness at a relative transmission of 0.5 will be the required HVL value.

11. Repeat steps 4 to 10: 3 point generators, 100 kV, 200 mA, 50 ms, large focus. For 2 point generators use 100 kV, 200 mA if this can be set, and 10 mAs. Use table 11 to record the values and figure 2 to plot the results

12. Table 12 and figure 3 show example HVL determination.

5.0 H.V.L. EVALUATION (Cont)

ADDED ALUMINUM FILTER	DOSE (mR)	RELATIVE TRANSMISSION
0		
0		
0		
0 (Average of three readings)		1.00
2		
1		
3		

Table 10: HVL dose values 80 kVp

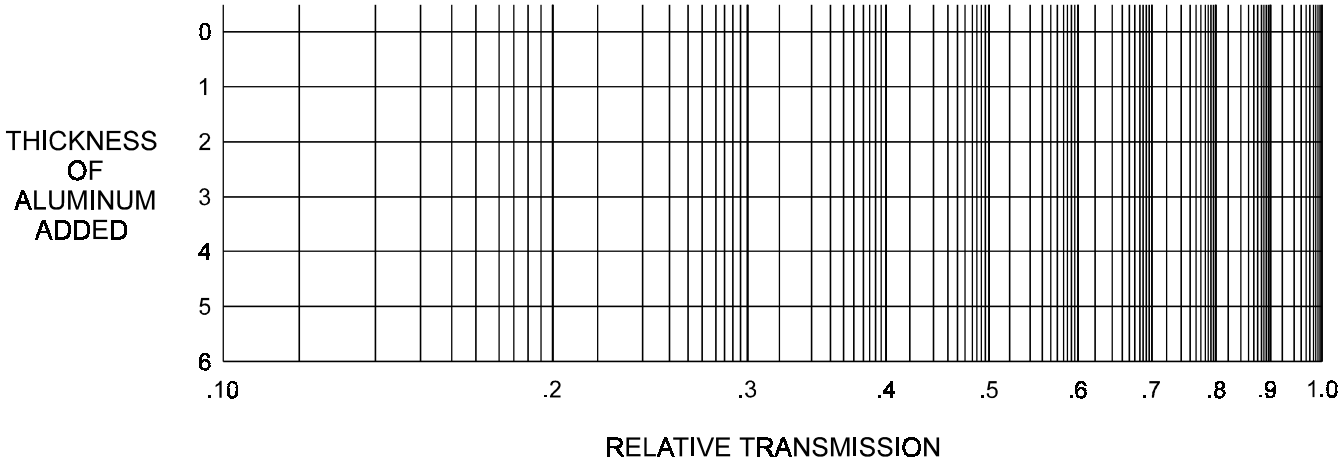

Figure 1: HVL plot 80 kVp

For 80 kVp, the HVL must be ≥ 2.3 mm Al.

5.0 H.V.L. EVALUATION (Cont)

ADDED ALUMINUM FILTER	DOSE (mR)	RELATIVE TRANSMISSION
0		
0		
0		
0 (Average of three readings)		1.00
2		
1		
3		

Table 11: HVL dose values 100 kVp

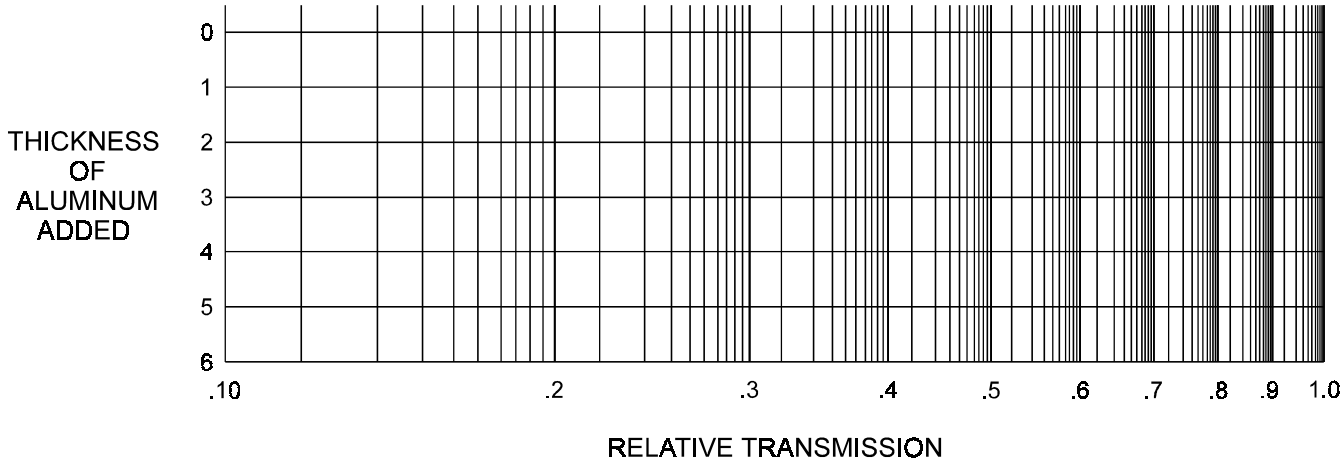

Figure 2: HVL plot 100 kVp

For 100 kVp, the HVL must be ≥ 2.7 mm Al.

5.0 H.V.L. EVALUATION (Cont)

ADDED ALUMINUM FILTER	DOSE (mR)	RELATIVE TRANSMISSION
0	249	
0	244	
0	247	
0 (Average of above three readings)	247	1.00
2	162	.66
1	131	.53
3	70	.28

Table 12: HVL dose values (example)

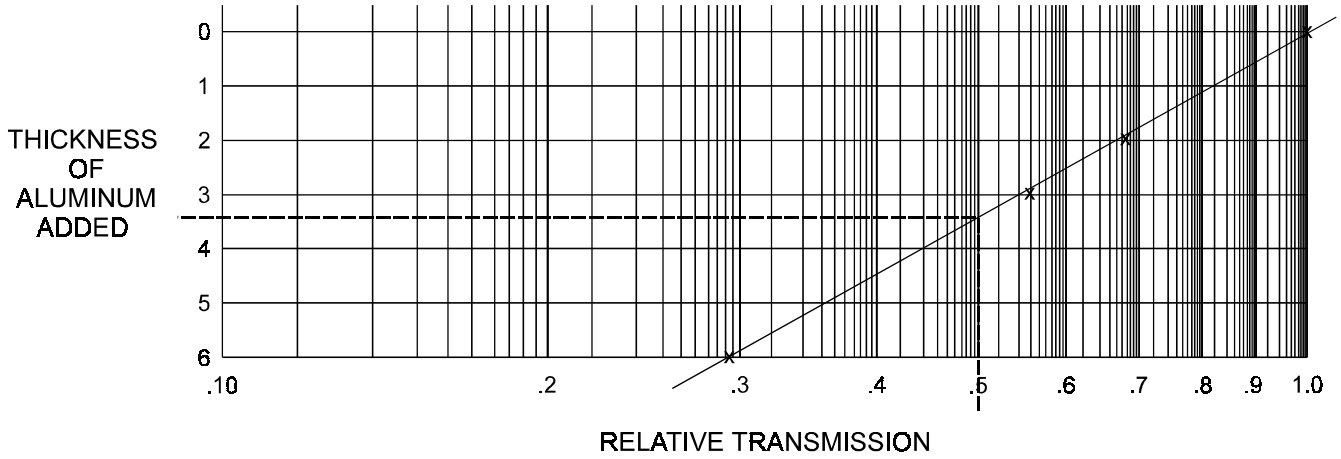

Figure 3: HVL plot (example)

By interpolating the thickness of Al at a relative transmission value of 0.5, it can be seen that the HVL is approximately 3.3.

CHAPTER 5

TROUBLESHOOTING

CONTENTS:

5.1.0 INTRODUCTION 5-2
5.2.0 STATUS AND ERROR CODES 5-2
5.2.1 Start-Up Messages 5-2
5.2.2 Status Messages 5-3
5.2.3 Limit Messages 5-3
5.2.4 Error Messages 5-4
5.3.0 STATUS LED'S *5-8*
5.4.0 MISCELLANEOUS FAULTS 5-9
5.4.1 Console Failure to Start 5-9

5.1.0 INTRODUCTION

The X-ray generator console will display status messages on the LCD display during normal and abnormal operation of the generator. This Chapter contains tables of those messages and suggests actions to be taken by service personnel to correct any malfunctions that may occur.

5.2.0 STATUS AND ERROR CODES

5.2.1 Start-Up Messages

These messages are displayed at initial power-on only, and indicate the status at the time that the generator is switched on.

MESSAGE	DESCRIPTION
AEC MEMORY O.K. / ERR	Indicates that the AEC data checksums match. ERR indicates that the AEC calibration data must be recreated by downloading via a laptop computer, or redoing the AEC adjustment procedure as per Chapter 3.
APR MEMORY: O.K. / ERR	O.K. indicates that the APR memory checksums match. ERR indicates an APR error. The APR data set should be recreated by downloading via a laptop computer, or changing any of the APR data and exiting.
CAL MEMORY: O.K. / ERR	O.K. indicates that the tube auto-calibration data checksums match. ERR indicates an auto cal error. The tube will need to be recalibrated.
HEAT SWITCH OPEN, TUBE MAY BE HOT	Indicates that the tube thermal switch is open or not connected.
LF DISABLED	Large focus has been disabled in programming.
LF UNCAL	The large focus is not calibrated, run the CALIBRATION routine.
MEMORY TEST: O.K. / ERR	O.K. indicates that the EPROM data checksums match. ERR indicates that the EPROM may be defective and should be replaced.
PROGRAM DATA: O.K. / ERR	Indicates that the mAs steps & error message checksums match. ERR indicates that the mAs step or error message checksums don't match. This suggests that the software needs to be replaced.
RELEASE EXP. SW.	Indicates that the exposure switch is closed while the generator is being powered-up.
RT CLOCK: O.K. / ERR	O.K. indicates that the time is being incremented by the RT clock. ERR indicates that the battery voltage may be low, or the clock may need setting as per Chapter 3.
SOFTWARE REV	Displays the software revision in the console.
SF DISABLED	Small focus has been disabled in programming.
SF UNCAL	The small focus is not calibrated, run the CALIBRATION routine.
STAMP ERROR: XX	Indicates that there was insufficient time to save the time stamp information before power was lost, or that the lithium battery on the CPU board is low. If this message appears check the battery on the CPU board, or set the clock as per Chapter 3.
TUBE CALIBRATED	Both focal spots are calibrated.
TUBE DATA: O.K. / ERR	O.K. indicates that the tube insert data checksums match. ERR indicates a tube data error. The tube data must be recreated by downloading via a laptop computer, or possibly the EEPROM is defective and needs to be replaced.
TUBE DISABLED. ENTER UTILITY TO ENABLE.	Both focal spots have been disabled in programming.

5.2.2 Status Messages

These messages indicate the status of the generator.

MESSAGE	DESCRIPTION
PREPARATION	Indicates that PREP has been requested.
READY	Indicates that the generator is ready to make an exposure.
X-RAY EXPOSURE	Indicates that an X-ray exposure is in progress.

5.2.3 Limit Messages

These messages indicate that an exposure has been requested that exceeds one or more limits.

MESSAGE	PROBLEM	ACTION
DENSITY LIMIT	The generator upper or lower density limit has been reached.	None required.
DUTY CYCLE LIMIT	Requested exposure not allowed until the duty cycle limit expires.	Wait for time limit to expire.
FOCUS CHANGED	Indicates that the focus has automatically changed while increasing or decreasing the mAs.	None required.
INVALID SETTING	Requested setting is invalid, ie attempting to deselect all AEC fields in AEC mode.	Correct the setting.
KVP LIMIT	The generator kVp limit has been reached.	None required.
LF MAS LIMIT	The generator large focus mAs limit has been reached.	Switch to small focus for mAs values < 1.0 mAS.
MAS LIMIT	The generator mAs limit has been reached.	None required.
MAX MAS LIMIT	The generator power limit has been reached.	None required.
POWER KV LIMIT	Displayed if kV ↑ is pressed when the generator has reached its power limit.	Reduce mAs if higher kVp is required.
POWER MAS LIMIT	Displayed if mAs ↑ is pressed when the generator has reached its power limit.	Reduce mAs.
SF MAS LIMIT	The generator small focus mAs limit has been reached.	Reduce mAs on small focus.
TUBE KW LIMIT	Displayed if requested parameter change will violate the tube data.	None required.
CALC. AEC RAMP LIMIT	Requested density correction will require a ramp voltage > 15.0V from AEC device.	Increase KVp and decrease density correction.
LOW RAMP LIMIT	Requested density correction will require a ramp voltage below noise threshold of AEC device (≅ 50mV)	Decrease KVp and increase density correction.

5.2.4 Error Messages

These messages indicate that an error has occurred.

MESSAGE	PROBLEM	ACTION
40 INCH ITLK	Indicates that the 40 ″ S.I.D. has been selected, but the tube stand is not in the 40 ″ S.I.D. position.	1. Check S.I.D. on tube stand. 2. Check the 25 pin console cable.
72 INCH ITLK	Indicates that the 72 ″ S.I.D. has been selected, but the tube stand is not in the 72 ″ S.I.D. position.	1. Check S.I.D. on tube stand. 2. Check the 25 pin console cable.
AEC INTERLOCK	Indicates that no AEC device is connected.	Connect AEC device or deprogram the AEC option.
BACKUP MAS	The AEC backup mAs timer, and not the AEC circuits, terminated the AEC exposure.	1. Check the BUmAs setting, as described on page 5-5. 2. Check the AEC chamber, wiring, and AEC board.
BACKUP TIMER	The generator backup timer terminated the exposure at the limit of 6000 ms for non AEC exposures, or the BUmAS limit for AEC exposures.	Increase the mA for non AEC exposures, or increase the BUmAs for AEC exposures.
DEVICE INTERRUPT	Indicates that the selected bucky is not ready.	Check the Bucky(s).
FAULTY EXP. SW.	Indicates that the exposure switch is closed during power-up. This message is displayed if the switch is not opened immediately after the RELEASE EXP. SW. message in 5.2.1. is displayed.	Check and replace the exposure switch if necessary.
FILAMENT FAULT	Indicates that filament current < 2.5 amps detected.	1. Check for open filament in X-ray tube. 2. Check for poor connections in the cathode HT cable. 3. Check the filament supply board.
FOCUS DISABLED	Indicates that the requested focal spot has been deprogrammed.	Select the other focal spot, or enable the selected focal spot in programming mode.
HEAT SW. ITR.	Indicates that the thermal switch has opened during an exposure.	Allow the X-ray tube to cool.

5.2.4 Error Messages (Cont)

MESSAGE	PROBLEM	ACTION
kV HIGH	Indicates measured kV is high by > 15 %.	1. Check power supply control board and/or HT tank. 2. Re-auto calibrate (per CALIBRATION in Chapter 3). 3. Consult product support.
kV LOW	Indicates measured kV is low by >15 %.	1. Check that the mains voltage is appropriate for the selected output power. 2. Check power supply control board and/or HT tank. 3. Re-auto calibrate (per CALIBRATION in Chapter 3). 4. Consult product support.
LOW / NO AEC RAMP	A low (or no) AEC ramp has been detected from the AEC chamber during the first 50 ms of AEC exposure.	1. Check settings (techniques, receptor selection, etc, and mA / mAs settings. Refer to the note at the bottom of this page). 2. Check AEC chamber, conections, wiring etc.
mA HIGH	Indicates measured mA is high by > 20 %.	1. Check for tube arcing. 2. Check power supply control board and/or HT tank. 3. Re-auto calibrate (per CALIBRATION in Chapter 3). 4. Consult product support.

NOTE: AEC backup mAs = mAs as set in non-AEC mode X 2 (i.e. @ 10 mAs, AEC backup mAs = 20 mAs).
AEC backup time = AEC backup mAs ÷ mA (i.e. 100 mAs ÷ 50 mA = 2 seconds AEC backup time).
The “Low / No AEC Ramp” fault limit varies depending on the AEC backup time. Reducing the AEC backup time increases the AEC fault reference voltage. Therefore, for short AEC backup times a larger AEC voltage ramp is require than for long AEC backup times. The formula below illustrates the relationship between AEC backup time and the minimum AEC voltage ramp that must be present at 50

5.2.4 Error Messages (Cont)

ms after the start of an AEC exposure.

$$Vramp\ (Min) = \left[\left(\frac{0.050 \times Vref}{AEC\ Backup\ Time} \right) 0.9 \right]$$

Vref varies from 0 to 5 V, depending on the technique. It can be seen that increasing the AEC backup time decreases the minimum required AEC voltage ramp.

MESSAGE	PROBLEM	ACTION
mA LOW	Indicates measured mA is low by > 20 %.	1. Check mains voltage. 2. Check power supply control board and/or HT tank. 3. Re-auto calibrate (per CALIBRATION in Chapter 3). 4. Consult product support.
MANUAL INTERRUPT	The X-ray exposure switch was released before the exposure was finished.	Hold the exposure switch until the exposure is finished.
POWER UP FAILURE, CHECK LINE VOLT.	Indicates that the generator did not power up within 30 seconds of the console being switched on.	1. Check that the mains voltage is not outside the low line specification. 2. Check the 37 conductor console cable. 3. Check the DC bus voltage. The DC bus capacitors may not be charging. 4. Check that the main contactor on the power input board is closed.
P/S FAULT	Indicates that the generator is not ready to make an exposure.	1. Check D1 on the auxiliary board. If this is lit, the + or - 12 VDC rails may be low. Check the +/- 12 V supplies on the auxiliary board. 2. Check PREP and kV ENABLE signals on the power supply control board. 3. Consult product support.

5.2.4 Error Messages (Cont)

MESSAGE	PROBLEM	ACTION
P/S NOT READY	Indicates that the main line contactor in the generator is not commanded to close. A DC bus fault may be preventing the DC bus capacitors from charging, in which case the contactor closure will be inhibited.	Check D1 on the auxiliary board. If this is lit, the contactor will not close. Check the DC bus assembly and the soft start circuit on the power input board if this is the case.
ROTOR FAILURE, TURN UNIT OFF	Indicates that the rotor is running at any time other than during prep or during an exposure.	Check rotor board or auxiliary board.
ROTOR FAULT	Indicates that the low speed starter board has not sensed adequate stator current.	1. Check the X-ray tube stator wiring. 2. Check the rotor board.
TUBE DISABLED	Both focal spots are disabled.	Enable one or both focal spots.
TUBE FAULT	Indicates a fault has been detected in the kV or mA output, or in the inverter circuits.	Check if D69, D70, D71, D72, or D82 on the power supply control board are lit. If any of the above LED's are lit, refer to the note at the end of this table for a description of the function of these LED's.
UNCOMMANDED KV	Indicates that kV feedback has been detected when no kV has been requested.	Switch generator OFF. Prevent further use of generator until problem is fixed.

NOTE RE ***TUBE FAULT*** *ERROR:*

As briefly described in the preceeding table, LED's D69, D70, D71, D72, or D82 on the power supply control board indicate the type of fault that caused the stated error.

- D69 indicates high kVp ≥ 130 kVp for 125 kV generators, ≥ 160 kVp for 150 kV generators. If this is lit, consult product support.
- D70 indicates that inverter (primary) current exceeded preset limits. If this is lit, consult product support.
- D71 indicates cathode current exceeded preset limits, usually due to an arc. If this is lit, check the X-ray tube. The X-ray tube may be damaged or simply require seasoning. Refer to Chapter 6 for TUBE CONDITIONING / SEASONING. If this does not solve the problem, check the HT cables and HT connections. Consult product support if the previous steps fail to resolve the problem.
- D72 indicates anode current exceeded preset limits, usually due to an arc. Follow the recommendations for D71.
- D82 indicates an inverter fault. If this is lit, consult product support.

5.3.0 STATUS LED'S

The following list describes the normal states and the functions of the status and diagnostic LED's on the circuit boards in the generator.

Power Input Board

LED	NORMAL STATE	FUNCTION
D2	Lit	Indicates that the DC bus voltage is sufficient to energize the main line contactor.
D9	Lit	Indicates that +12 VDC is present on the power input board. This LED does NOT indicate that the +12 VDC rail is within normal limits.

Auxiliary Board

LED	NORMAL STATE	FUNCTION
D1	Off	Indicates that the + or - 12 VDC rails are low, or that a DC bus (soft start) fault is present. See D2 under power input board.
D2	Lit	Indicates that the logic is OK for the main line contactor to close.
D3	Lit	Indicates that the power input board logic is OK to allow the main line contactor to close.
D29	Lit	Indicates that the +12 VDC supply on the auxiliary board is present. This LED does NOT indicate that the +12 VDC rail is within normal limits.
D30	Lit	Indicates that the -12 VDC supply on the auxiliary board is present. This LED does NOT indicate that the -12 VDC rail is within normal limits.
D31	Lit	Indicates that the + and - 35 VDC supplies on the auxiliary board are present. This LED does NOT indicate that the these supplies are within normal limits.

Control Board

LED	NORMAL STATE	FUNCTION
D69	Off	Refer to "*NOTE RE **TUBE FAULT** ERROR" at end of 5.2.4.*
D70	Off	Refer to "*NOTE RE **TUBE FAULT** ERROR" at end of 5.2.4.*
D71	Off	Refer to "*NOTE RE **TUBE FAULT** ERROR" at end of 5.2.4.*
D72	Off	Refer to "*NOTE RE **TUBE FAULT** ERROR" at end of 5.2.4.*
D82	Off	Refer to "*NOTE RE **TUBE FAULT** ERROR" at end of 5.2.4.*

Customer Interface Board

LED	NORMAL STATE	FUNCTION
DS1	Lit	Indicates the presence of +24 VDC on this board.

CPU Board

LED	NORMAL STATE	FUNCTION
DS7	Lit	Indicates the presence of +24 VDC on this board.

5.4.0 MISCELLANEOUS FAULTS

5.4.1 Console Failure to Start

SYMPTOM: LCD display on console lights up when console switched ON, but start up diagnostics, etc do not display.

SOLUTION: Check battery B1 on CPU board. The console will not start executing the firmware code if the battery is missing, or if the battery voltage is very low ≤ 1 V.

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CHAPTER 6

REGULAR MAINTENANCE

CONTENTS:

6.1.0 INTRODUCTION 6-2
6.2.0 SERVICE RECORD 6-3
6.3.0 MAINTENANCE SCHEDULE 6-4
6.4.0 OIL FILL / LEVEL CHECK 6-4
6.5.0 CLEANING 6-6
6.6.0 EPROM / EEPROM REPLACEMENT 6-6
6.7.0 BATTERY REPLACEMENT 6-6
6.8.0 TUBE CONDITIONING / SEASONING 6-8
6.9.0 AEC / CAEC BOARD INSTALLATION OR REPLACEMENT 6-9

6.1.0 INTRODUCTION

This Chapter provides a recommended schedule for periodic maintenance of the X-ray generator. Instructions are also included for installing an AEC / CAEC board in generators which originally did not have the AEC option installed, and for installing an AEC / CAEC board to upgrade to CAEC (where available).

The initial installation date and location, and all service performed on the generator, should be recorded in table 6-1. The record should be as thorough as possible, detailing the scope and type of work that was performed (all service and a record of all replacement parts that were installed). Additionally, the person performing the work should date and sign the record.

This information will be invaluable in the future for traceability and to ensure continued compatibility of the generator.

If a major component (such as the HT oil tank or a major circuit board) is replaced, recalibration will be needed. A separate procedure will be included with the spare in those cases, detailing the required calibration procedure. The acceptance test procedure per Chapter 4 should then be performed prior to placing the generator back into service.

WARNING:	***MAINTENANCE IS TO BE PERFORMED ONLY BY COMPETENT, TRAINED PERSONNEL WHO ARE FAMILIAR WITH THE POTENTIAL HAZARDS ASSOCIATED WITH THIS EQUIPMENT.***

NOTE:	***MAINTENANCE SCHEDULE FREQUENCY MAY BE DICTATED BY CERTAIN REGULATORY REQUIREMENTS OF THE COUNTRY OR STATE IN WHICH THE INSTALLATION IS LOCATED. ALWAYS CHECK THE LOCAL CODES AND REGULATIONS WHEN SETTING THE MAINTENANCE SCHEDULE.***

WARNING:	***ALWAYS SWITCH OFF MAINS POWER TO THE GENERATOR AND WAIT A MINIMUM OF 5 MINUTES FOR CAPACITORS TO DISCHARGE BEFORE BEGINNING ANY PREVENTATIVE MAINTENANCE, INCLUDING CLEANING.***

6.2.0 SERVICE RECORD

INSTALLED BY: _____ DATE: _____ LOCATION: _____		
Service Date	**Description of Service**	**Performed By**

Table 6-1: Installation and service record

6.3.0 MAINTENANCE SCHEDULE

Maintenance Frequency	Description of Preventative Maintenance
Every 6 Months AND whenever a related certifiable X-ray component is replaced:	1. Clean and re-grease all HV connections using vapor proof compound. 2. Check that all HV connections are tight. 1. Clean the control console, and main cabinet as needed. **REFER TO 6.5.0 CLEANING BEFORE PROCEEDING.** 2. Perform the X-ray tube auto calibration routine, refer to Chapter 3. 1. Verify the calibration of the generator, refer to Chapter 4. 2. Test the X-ray tube thermal switch circuits in the generator. Disconnect the tube thermal switch and verify the correct error message, and that X-ray exposures are inhibited. 1. Perform any additional tests required by laws governing this installation.
Every 12 months:	1. Examine the following for any visible damage and replace any damaged components: • The exterior of the control console, including the membrane switch assembly. • The cables between the control console and the generator main cabinet. • The cable(s) between the control console and the AEC chambers (if the AEC option is used). • The handswitch (if used) and the cables connecting this to the console. • The HT cables. 2. Open the generator main cabinet and examine the unit for any visible damage: missing or loose ground connections, oil leaks, damaged cables etc. 3. Ensure that there are no obstructions blocking any of the ventilation holes or louvers on the generator cabinet.
Every 5 years:	Replace the lithium battery on the CPU board in the control console. Refer to the spares list in Chapter 8 for the required part number. Refer to 6.7.0 for the battery replacement procedure.

6.4.0 OIL FILL / LEVEL CHECK

The insulating oil level in the HT transformer does NOT require periodic checking under normal conditions. However, if there is evidence of possible oil loss, the procedure for checking the correct oil level follows.

1. Loosen the oil fill plug screw on the tank lid.

2. With the screw sufficiently loosened, remove the rubber (neoprene) plug.

6.4.0 OIL FILL/LEVEL CHECK (Cont)

3. Measure the oil level from the TOP surface of the HT tank lid board using a **clean** ruler, or clean strip of cardboard or equivalent. The oil level should be in the range of 7/8" (23 mm) to 1 5/16" (33 mm) from the top of the HT tank lid board. If the oil level is less than 1/2" (13 mm) low i.e. not greater than 1 13/16" (46 mm) below the top of the tank lid board, then oil may be added as needed (see below). If the oil level is greater than 1 13/16" (46 mm) from the top, consult the factory.

4. Use only fresh oil, type Shell DIALA AX or equivalent. Take care not to damage delicate components inside the tank if using a funnel for oil fill.

5. Replace the oil fill plug and tighten the screw when finished. Do NOT over tighten the screw. This should be tightened until the neoprene plug is no longer able to be turned by hand, then tighten the screw another 1 to 1 1/2 turns. Wipe up any oil spills. Dispose of soiled absorber in compliance with government requirements, and ensure conformity to local disposal regulations.

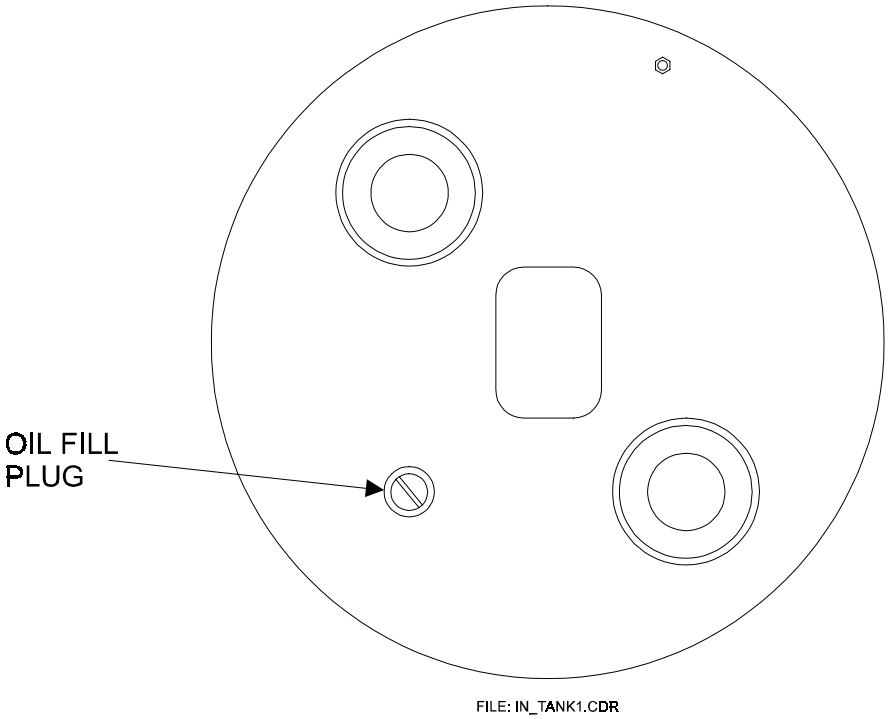

Figure 6-1: HT tank oil fill

6.5.0 CLEANING

- Never use anything other than mild soap and water to clean plastic surfaces. Other cleaners may damage the plastic.
- **Never use any corrosive, solvent or abrasive detergents or polishes.**
- Ensure that no water or other liquid can enter any equipment. This precaution prevents short circuits and corrosion forming on components.
- Methods of disinfection used must conform to legal regulations and guidelines regarding disinfection and explosion protection.
- If disinfectants are used which form explosive mixtures of gases, these gases must have dissipated before switching on the equipment again.
- Disinfection by spraying is not recommended because the disinfectant may enter the X-ray equipment.
- If room disinfection is done with an atomizer, it is recommended that the equipment be switched OFF, allowed to cool down and covered with a plastic sheet. When the disinfectant mist has subsided, the plastic sheet may be removed and the equipment be disinfected by wiping.

6.6.0 EPROM / EEPROM REPLACEMENT

WARNING: ***PLEASE TAKE APPROPRIATE ELECTROSTATIC PRECAUTIONS AT ALL TIMES WHEN HANDLING THE EPROM OR EEPROM.***

1. Switch the generator OFF at the console and disconnect the mains voltage.
2. Turn the console on its face. A soft, clean cloth should be placed on the work surface to protect the console from damage while it is face down.
3. Remove and temporarily set aside the screws at the bottom of the console. Carefully remove the bottom of the console enclosure.
4. Locate and carefully remove the existing EPROM and / or EEPROM on the CPU board (U7 for the EPROM, U6 for the EEPROM, refer to figure 6-2).
5. Carefully insert the replacement EPROM and / or EEPROM into the socket *observing the orientation per figure 6-2*.
6. Reposition the console bottom and replace the hardware that was removed in step 3.

6.7.0 BATTERY REPLACEMENT

1. Refer to 6.6.0 for console disassembly instructions to access the CPU board. Refer to figure 6-2 for the battery location.
2. Remove the battery from the holder by gently prying under the battery at the access slot in the battery holder using a small screwdriver. Slide the battery over the edge of the holder and remove it when it is free.
3. Check the voltage of the new battery prior to inserting it. This should be nominally 3.2V, do not use if it is under 2.90 V.
4. Wipe the replacement battery with a clean cloth, and ensure that the holder is clean before inserting the new battery.

6.7.0 BATTERY REPLACEMENT (cont)

5. Gently lift the spring contact on the holder and insert the replacement battery positive (+) side up

6. A stamp error message may be observed at initial turn-on after replacing the battery. This is normal at this point and will be cleared by setting the date and time in step 8.

7. Reassemble the console as per 6.6.0.

8. Reset the date and time; refer to Chapter 3 for the procedure to do this.

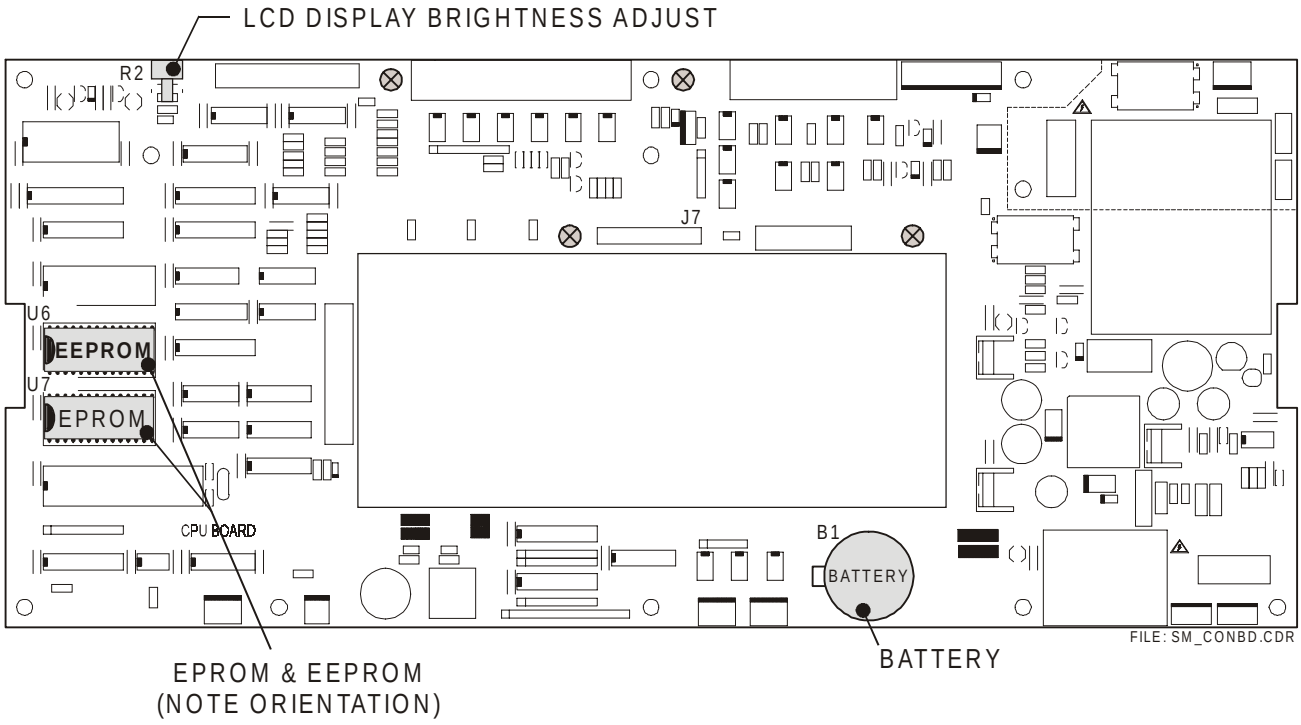

Figure 6-2: EPROM and battery location

6.8.0 TUBE CONDITIONING / SEASONING

Tube conditioning or “seasoning” is particularly important for new X-ray tubes or tubes that have not been used for several days. This should be performed before attempting auto calibration, as an unseasoned tube may not operate properly at higher kV values without arcing.

Always refer to the X-ray tube manufacturers seasoning procedure, if available. If the X-ray tube manufacturers instructions are not available, the following procedure may be used:

IF DEVIATING FROM THE PROCEDURE BELOW, IT MUST BE UNDERSTOOD THAT THE GENERATOR WILL NOT ALLOW EXPOSURES AT KV VALUES HIGHER THAN HAS BEEN AUTO CALIBRATED. FOR EXAMPLE, IF AUTO CALIBRATION HAS ONLY BEEN DONE AT 40 AND 70 KV, THEN EXPOSURES ABOVE 70 KV ARE NOT ALLOWED.

TUBE AUTO CALIBRATION IS DONE AT 40 kV, 70 KV, AND 100 KV FOR 125 KV GENERATORS, AND ADDITIONALLY AT 125 KV FOR 150 KV GENERATORS.

1. In the level 2 utilities menu record the current maximum kV setting, then temporarily set the maximum kV to 80. Refer to Chapter 3 for the procedure to do this.

2. Start the tube auto calibration sequence, and allow the generator to finish the 70 kV calibration step. Calibration will not be attempted beyond 70 kV due to the kV limit set in step 1.

3. Season the tube at 70 kV, large focus, 300 mA, by taking approximately 10 exposures of 50 mAs. These exposures should be taken at the maximum rate that the duty cycle limit will allow.

4. Temporarily set the maximum kV to 110 kV as per step 1.

5. Restart the tube auto calibration sequence, and allow the generator to finish the 100 kV calibration step. For 125 kV generators, 100 kV is the highest kV value used for auto calibration. For 150 kV generators, calibration will not be attempted beyond 100 kV due to the kV limit set in the previous step. ***THE GENERATOR WILL BEGIN AUTO CALIBRATION AT 40 KV EACH TIME THE AUTO CALIBRATION SEQUENCE IS RESTARTED IN THIS PROCEDURE.***

6. Season the tube at 100 kV, large focus, 300 mA, by taking approximately 10 exposures of 50 mAs. These exposures should be taken at the maximum rate that the duty cycle limit will allow.

For 125 kVp generators, follow steps 7 and 8.

7. Reset the maximum kV to the value that it was in step 1 prior to the temporary change.

8. Season the tube at 120 kV, large focus, 300 mA, if the kV limit allows this, by taking approximately 5 exposures of 50 mAs. These exposures should be taken at the maximum rate that the duty cycle limit will allow.

For 150 kVp generators, follow steps 9 to 12.

9. Temporarily set the maximum kV to 130 kV as per step 1.

10. Season the tube at 120 kV, large focus, 300 mA, by taking approximately 5 exposures of 50 mAs. These exposures should be taken at the maximum rate that the duty cycle limit will allow.

11. Restart the tube auto calibration sequence and allow the generator to finish the 125 kV calibration step. This is the highest kV value used for auto calibration.

12. Reset the maximum kV to the value that it was in step 1 prior to the temporary change.

6.9.0 AEC / CAEC BOARD INSTALLATION OR REPLACEMENT

1. Switch the generator OFF at the console and disconnect the mains voltage.

2. Turn the console on its face. A soft, clean cloth should be placed on the work surface to protect the console from damage while it is face down.

3. Remove and temporarily set aside the screws at the bottom of the console. Carefully remove the bottom of the console enclosure.

4. If an existing AEC board is to be replaced, follow these steps:
   a) Locate the four nylon standoffs that secure the AEC board to the CPU board.
   b) Turn the head of each plunger approximately 90° counterclockwise to release the latches. Refer to figure 6-3.
   c) Note the orientation of the existing AEC board, then gently lift the existing AEC board off the nylon standoffs.
   d) Orientate the replacement AEC board such that it will fit onto the existing nylon standoffs. Ensure that the pins on J7 on the CPU board are lined up with the mating connector on the AEC board, then press the AEC board into position such that the J7 connector pins and the AEC board are fully seated. When the AEC board is properly installed, turn the head of each plunger approximately 90° clockwise to secure the board. ***Ensure that there is a minimum of 1/16" (2 mm) clearance between the heatsink of Q3 on the CPU board and the bottom of the AEC board. If there is insufficient clearance, gently bend Q3 toward J1 on the CPU board until sufficient clearance is available.***
   e) Reposition the console bottom and replace the hardware that was removed in step 3.
   f) Connect the AEC cables as per chapter 2, then perform AEC setup and calibration per chapter 3 of the service manual.

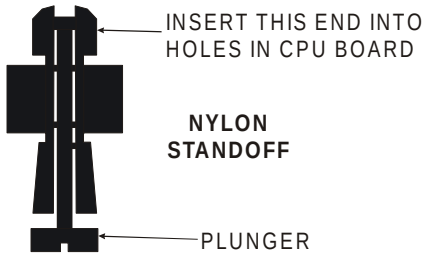

Figure 6-3: Nylon standoff

5. If an AEC board is to be installed in a generator that previously had no AEC board, follow these steps:
   a) Locate the four AEC board mounting holes on the CPU board. These are indicated ⊗ in figure 6-2.
   b) Install a nylon standoff in each mounting hole identified in the previous step. Press the end of the standoff shown in figure 6-3 into the holes in the board, and then fully depress the plunger on the nylon standoffs to secure the standoffs to the board.

6.9.0 AEC / CAEC BOARD INSTALLATION OR REPLACEMENT (Cont)

c) Orientate the AEC board to be installed with the component side up, and the connectors facing the rear of the console such that it will fit on the nylon standoffs. Ensure that the pins on J7 on the CPU board are lined up with the mating connector on the AEC board, then press the AEC board into position such that the J7 connector pins and the AEC board are fully seated. When the AEC board is properly installed, turn the head of each plunger approximately 90° clockwise to secure the board. ***Ensure that there is a minimum of 1/16" (2 mm) clearance between the heatsink of Q3 on the CPU board and the bottom of the AEC board. If there is insufficient clearance, gently bend Q3 toward J1 on the CPU board until sufficient clearance is available.***

d) Reposition the console bottom and replace the hardware that was removed in step 3.

e) Connect the AEC cables as per chapter 2, then perform AEC setup and calibration per chapter 3 of the service manual.

CHAPTER 7

THEORY OF OPERATION

CONTENTS:

7.0 INTRODUCTION 7-2
7.1 FUNCTIONAL OVERVIEW 7-2
7.1.1 Power Input Board 7-2
7.1.2 Resonant Board 7-2
7.1.3 Low Speed Starter Board 7-2
7.1.4 Auxiliary Board 7-3
7.1.5 Filament Board 7-3
7.1.6 Power Supply Control Board 7-3
7.1.7 Inverter Board 7-4
7.1.8 DC Bus Assembly 7-4
7.1.9 Customer Interface Board 7-4
7.1.10 CPU Board 7-4
7.1.11 AEC Board (Optional) 7-4
7.2.0 HT TANK 7-5

7.0 INTRODUCTION

This Chapter provides an overview of the main functional blocks in the generator.

7.1 FUNCTIONAL OVERVIEW

This X-ray generator contains the power input board, resonant board, low speed starter board, auxiliary board, filament board, power supply control board, inverter board, DC bus assembly, customer interface board, and the HT oil tank in the main cabinet. The console houses the CPU board and optional AEC board. Each of these boards will be described briefly in the following subsections.
The HT tank will be briefly discussed in this Chapter also.

7.1.1 Power Input Board

The AC mains power is connected to the main generator fuses on this board. When the main line contactor K5 on the power input board is closed, the mains voltage is switched to the DC bus assembly for rectification and filtering. The mains voltage is also fed to the other generator circuits from this board as required.

The soft start circuit, which precharges the DC bus capacitors prior to the main line contactor closing, is located on the power input board. A DC bus voltage detector circuit is also located on this board. This circuit generates a signal that prevents the main contactor from closing should a DC bus fault be detected that prevents the DC bus from charging normally.

7.1.2 Resonant Board

The resonant board contains the inverter resonant components (capacitor and inductors), and a current transformer which monitors the inverter current. A sample of the inverter current is then fed to the power supply control board where it is measured to ensure that it is within safe limits. Circuits on the power supply control board also use this sampled inverter current to synchronize the drive pulses to the inverter board.

7.1.3 Low Speed Starter Board

The low speed starter board is mounted on the power input board and supplies the boost and run voltages to R type stator tubes. The boost time of approximately 1.5 seconds is controlled by a timer circuit on the auxiliary board. This timer starts when the prep command is received, causing the low speed starter to output approximately 230 VAC to the stator windings in the X-ray tube to rapidly bring the stator up to rated speed. After the 1.5 second boost time has expired, the stator voltage drops to approximately 50 VAC to maintain this speed for the duration of the X-ray exposure.

Current sense relays on the low speed starter board monitor the current in both the main and shift windings. If either of these currents is low or absent, a rotor fault signal is sent to the auxiliary board and then to the power supply control board for processing.

7.1.4 Auxiliary Board

The auxiliary board contains the + and - 12 VDC supplies, and the + and - 35 VDC supplies, as well as the undervoltage detection circuit for the + and - 12 VDC supplies. The undervoltage fault signal is sent to the power supply control board for further processing by logic circuits on that board.

The auxiliary board also processes the signal from the DC bus voltage detector on the power input board. If the DC bus voltage detector senses that the DC bus capacitors are not charging normally, circuits on the auxiliary board will prevent the the main line contactor from closing. The P/S not ready fault signal from the auxiliary board is routed to the power supply control for further processing.

The auxiliary board also contains the rotor boost timer and rotor fault detector circuits as discussed in 7.1.3.

7.1.5 Filament Board

The filament board contains the filament control, filament driver, filament monitoring, and filament fault circuits. The filament control circuit generates drive signals which cause the filament driver to produce filament primary current. This filament primary current is switched by a relay on the filament board. The primary current is then routed to either the large filament transformer, or to the small filament transformer in the HT tank. The large filament transformer supplies filament current to the large filament in the X-ray tube, while the small filament transformer supplies filament current to the small filament in the X-ray tube. The large / small switching command for the filament select relay originates on the console CPU board, and is routed through the power supply control board to the filament board.

The filament current monitoring circuit samples the filament primary current, and is used to adjust the drive signal such that the actual filament current is equal to the demanded filament current. The filament current monitoring circuit will also generate a fault signal if the filament current is less than approximately 2 amps. This filament fault signal is processed by the power supply control board.

7.1.6 Power Supply Control Board

The control signals from the CPU board in the console are routed directly to the power supply control board. Logic circuits on the power supply control board ensure that the proper signals and commands from the console are present before an X-ray exposure can be made.

These logic circuits also monitor key fault indicators and inhibit an exposure if any of these faults are present. Signals indicating the presence of faults are sent by the power supply control board back to the console, where an error message will be displayed on the console LCD screen. The faults that are reported by the power supply control board include rotor fault, filament fault, tube arc fault (which as noted in Chapter 5 may be generated by any one of five fault detector circuits), and power supply not ready fault. Additionally, a P/S fault signal is generated that will inhibit exposures if any of the previous faults is present, or if the + or - 12 VDC supplies are low.

Circuits on the power supply control board generate drive pulses for the inverter board. The power supply control board also contains kV feedback and monitoring circuits which constantly monitor the kVp output and adjust the drive pulses to the inverter such that the actual kVp is equal to the kVp demanded. Therefore, the power supply control board performs the kVp regulation function.

Lastly, the power supply control board contains mA feedback and monitoring circuits. These circuits monitor the X-ray tube current and send a voltage which is proportional to the tube current back to the console where it is used by the console to automatically regulate the mA.

7.1.7 Inverter Board

The inverter board contains the high current FETs which drive the resonant circuit and the primaries of the HT transformers in the HT tank. The power supply control board generates the inverter drive signal. This drive signal causes the full bridge configured FETs to switch the nominal 600 VDC bus voltage to the HT transformer primaries. The secondary voltage produced by the HT transformers is determined by the frequency at which the DC bus voltage applied to the HT transformers is switched. This is governed by the control board, and is determined by comparing the actual kVp to the demanded kVp and constantly making corrections such that the demanded kVp is equal to the requested kVp.

7.1.8 DC Bus Assembly

The DC bus assembly contains the DC bus capacitors and the mains rectifier. The DC bus capacitors are precharged via current limiting resistors on the power input board and the mains rectifier on the DC bus assembly when the generator is switched on. This limits the inrush current drawn by the generator at initial turn-on. Once the capacitors are sufficiently pre-charged, the main contactor will supply mains voltage to the DC bus assembly where it is rectified and filtered by a voltage doubler circuit which produces approximately 600 VDC. This nominal 600 VDC output from the DC bus assembly is fed to the inverter board as described above.

7.1.9 Customer Interface Board

The customer interface board contains terminal blocks for the table and wall Bucky, for the S.I.D. interlocks, and for the X-ray tube thermal switch. Also on this board is a terminal block for the 24 VAC output for the collimator lamp and for the 24 VDC output for system locks. The customer interface board connects to the CPU board in the console via a 25 conductor cable.

7.1.10 CPU Board

The CPU board in the console contains the microprocessor, EPROM, EEPROM, analog to digital and digital to analog converters, memory decoders and associated circuits. Analog circuits send and receive analog information to and from the power supply control board (kVp demand, kVp feedback, filament demand, mA feedback), and digital circuits send and receive digital information to and from the power supply control board (example X-ray command, prep command, rotor fault, filament fault etc). Signals from the CPU board are also sent to and from the room interface board (room interlocks, thermal switch, Bucky drive and ready signals), to and from the AEC board, to and from the keypad, and to and from the console LCD display.

7.1.11 AEC Board (Optional)

The ramp from the AEC chamber is buffered by the AEC board input circuits, then it is fed to a gain stage for further processing. The ramp voltage is then routed to the CPU board, where it is monitored by the CPU. The CPU calculates in software the expected ramp voltage for each technique. The exposure is then terminated by the console when the magnitude of the ramp equals the precalculated value.

The AEC board also contains switching circuits which perform AEC field selection, and switch the AEC ramp from either the table Bucky or the wall Bucky to the common buffer and amplifier circuits.

7.2.0 HT TANK

The HT tank contains two HT transformers, one for the anode and one for the cathode. The cathode transformer along with its rectifier and filter capacitors generates up to - 62.5 kVp for 125 kV generators, or - 75 kVp for 150 kV generators. The anode transformer along with its rectifier and filter capacitors generates up to + 62.5 kVp for 125 kV generators, or + 75 kVp for 150 kV generators.

The kVp output and the X-ray tube current is sampled and fed back to the power supply control board via J9 on the HT tank. The HT tank also has an mA / mAs test jack E17 - E18 which allows the actual tube current to be measured if the shorting link is removed and an approved mA / mAs meter is connected.

Filament transformers are also located in the HT tank. The output from the filament board is applied to the primaries of these transformers, the secondaries then couple the filament current to the filaments in the X-ray tube. The filaments float at cathode potential, therefore the filament transformer secondaries also provide the necessary high voltage isolation of the cathode.

The HT tank is not field serviceable. The oil must be vacuum filled to purge all trapped air, otherwise the tank will not be able to withstand the rated kVp. This cannot be done in the field.

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CHAPTER 8

SPARES

CONTENTS:

8.1.0 INTRODUCTION 8-2
8.2.0 SPARE PARTS LIST GENERATOR MAIN CABINET 8-2
8.3.0 SPARE PARTS LIST OPERATOR CONSOLE 8-3
8.4.0 SPARE PARTS LIST CONSOLE CABLES 8-3

8.1.0 INTRODUCTION

This chapter contains the list of spare parts for the 30, 32.5, 37.5 kW single phase X-ray generator, and for the 50 kW three phase X-ray generator.

8.2.0 SPARE PARTS LIST GENERATOR MAIN CABINET

DESCRIPTION	PART NUMBER	NOTE	SUGGESTED QTY
Power input board	See note ⇒	2	⇐ See note
Resonant Board	See note ⇒	3	⇐ See note
Low speed starter board	732752-00	1	1
Auxiliary board	732221-02	4	1
Filament board	731407-00	1	1
Power supply control board	732816-03	5	1
Inverter board	See note ⇒	6	⇐ See note
Customer interface board	735139-00	1	1
Contactor, line	SC2715	1	1
Capacitor, DC bus 9000 uF 400 VDC	4155001400	7	See note 7
Capacitor, DC bus 470 uF 450 VDC	4150394100	8	See note 8
Diode, mains rectifier DD89N12K, DD90N12L, or IRKD91-12	6623507000	7	See note 7
Diode, mains rectifier 160MT120K	6623071100	8	See note 8
Fuse, AGC-3	SC2757	8	See note 8
Fuse, FNM-3	6711907400	1	5
Fuse, FNQ-1	6711905800	8	See note 8
Fuse, FNQ-10	6711905500	8	See note 8
Fuse, GDC-1.6	5550033300	1	5
Fuse, GDC-2	5550032600	1	5
Fuse, GDC-4	5550033100	1	5
Fuse, GDC-6.3	5550033400	1	5
Fuse, MDA-3	6712900600	7	See note 7
Fuse, MDA-5	6713000100	1	5
Fuse, MDA-7	6713000500	1	5
Fuse, MDA-10	6713000200	7	See note 7
Fuse, MDA-12	6713746500	1	5
Fuse, MDL 1 1/2	6713541500	7	See note 7
Fuse, MDL-4	6713544000	1	5
Fuse, NLN-100	6711906500	7	See note 7
Fuse, OTS-60	SC3434	8	See note 8

8.2.0 SPARE PARTS LIST GENERATOR MAIN CABINET (Cont)

DESCRIPTION	PART NUMBER	NOTE	SUGGESTED QTY
Transformer, aux power supply	732417-00	1	1
Transformer, room interface	735889-00	7	See note 7
Transformer, room interface	732415-00	8	See note 8
HT tank assembly (complete)	731547-05	7	See note 7
HT tank assembly (complete)	731547-02	8	See note 8

8.3.0 SPARE PARTS LIST OPERATOR CONSOLE

DESCRIPTION	PART NUMBER	NOTE	SUGGESTED QTY
CPU board	See note ⇒	10	⇐ See note
AEC board	735206-00	9	See note 9.
Switch / overlay assembly	735143-00	1	1
Display assy, LCD	733396-00	1	1
Battery, lithium 3.0V	7412290100	1	1

8.4.0 SPARE PARTS LIST CONSOLE CABLES

DESCRIPTION	PART NUMBER	NOTE	SUGGESTED QTY
Cable assembly, 25 conductor, 25 ft	735169-00	11	See note 11
Cable assembly, 37 conductor, 25 ft	735170-00	11	See note 11
Cable assembly, 25 conductor, 50 ft	735169-01	11	See note 11
Cable assembly, 37 conductor, 50 ft	735170-01	11	See note 11

NOTE:

1. The part number shown is used on all versions of this X-ray generator. These parts are not model or option dependent.

2. 30, 32.5, and 37.5 kW, 1 phase generators use power input board part number 733798-02; 50 kW, 3 phase generators use power input board part number 732161-03. Spares should be stocked accordingly.

3. 30, 32.5, and 37.5 kW, 1 phase generators use resonant board part number 732808-04; 50 kW, 3 phase generators use resonant board part number 732808-01. Spares should be stocked accordingly.

4. The part number shown is the suggested replacement for the original auxiliary board. The spares board is “jumper configurable” in the field, and as such will replace the original auxiliary board. This is intended to eliminate the need to stock multiple configurations of this board.

NOTE Cont):

5. The part number shown is the suggested replacement for the original power supply control board. The spares board is “full featured” and will replace the original board in your generator regardless of configuration. This is intended to eliminate the need to stock multiple configurations of this board.

6. 30, 32.5, and 37.5 kW, 1 phase generators use inverter board part number 732813-00; 50 kW, 3 phase generators use inverter board part number 732813-04. 30, 32.5, and 37.5 kW generators require one inverter board, 50 kW generators require two inverter boards. Spares should be stocked accordingly.

7. This item is used on 30, 32.5, and 37.5 kW, 1 phase generators only. Spares should be stocked accordingly.

8. This item is used on 50 kW, 3 phase generators only. Spares should be stocked accordingly.

9. This item only used on generators fitted with the optional AEC board. Spares should be stocked accordingly.

10. 30, 32.5, and 37.5 kW generators use CPU board part number 735133-00, 50 kW generators use CPU board part number 735133-01. Spares should be stocked accordingly.

11. Subject cables are available in 25 foot and 50 foot lengths. Spares should be ordered and stocked to suit the desired cable lengths.

CHAPTER 9

SCHEMATICS

CONTENTS:

9.1.0 INTRODUCTION 9-2
9.2.0 SCHEMATIC INDEX 9-2

9.1.0 INTRODUCTION

This chapter contains the schematics for your X-ray generator, placed in order per the schematic index (section 9.2.0).

RESTRICTION ON USE, DUPLICATION OR DISCLOSURE OF PROPRIETARY INFORMATION

This chapter (the schematics) contains information proprietary to the manufacturer, to its affiliates or to a third party to which the manufacturer may have a legal obligation to protect such information from unauthorized disclosure, use or duplication. Any disclosure, use or duplication of this document or of any of the information contained herein for other than the specific purpose for which it was disclosed by the manufacturer is expressly prohibited, except as the manufacturer may otherwise agree in writing.

9.2.0 SCHEMATIC INDEX

The following schematics are included in this manual.

DESCRIPTION	SCHEMATIC #
Power input board, 1 phase generators	733796
Power input board, 3 phase generators	732159
Resonant board	732806
Low speed starter board	732750
Auxiliary board	732219
Filament board	731405
Power supply control board	732814
Customer interface board	735137
CPU board	735131
AEC board	735204